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KEY

# BOEING 747

## Jumbo Jet

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Variants ✈️  
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Revamp**  
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**The  
747-8**  
A Test Pilot's  
View





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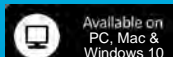
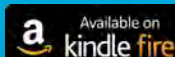
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# "Queen of the Skies" Continues to Reign

Nearly 50 years ago, a Boeing engineer named Joe Sutter had a dream. He imagined an aeroplane that would connect the world in ways never seen before – a vision that would become a reality in the iconic form of the 747.

Today, his dream continues to fly. The 747-8 is the latest derivative of the jumbo jet. The -8 retains the wonder of the 747, but with extensive redesigns that meet airline needs for efficiency, speed, range and customer comfort. Utilising many of the design features of the 787 Dreamliner, this timeless aeroplane continues to amaze

passengers, airlines, and cargo carriers. Every day I am captivated by how something so large can be so elegant.

The first deliveries of the 747-8 Freighter in 2011 and 747-8 Intercontinental in 2012 marked the end of an intense development programme, reminiscent of the mobilisation that led to the creation of the original 747 in the 1960s. Thousands of people worked to design, build, test and certify the 747-8. The result is nothing short of incredible, just like the team appropriately named 'The Incredibles' that formed around Joe in the 1960s.

Whether transporting world leaders or

exotic, over-sized cargo, the 747-8 provides capacity, comfort, and cargo flexibility that makes it stand out against other aeroplanes. The "Queen of the Skies" continues to reign, with its familiar and majestic presence. Modern yet familiar; immense yet graceful.

There's no other aeroplane like it. There never will be.



**Bruce Dickinson**  
Vice President and  
General Manager  
747/767 Program

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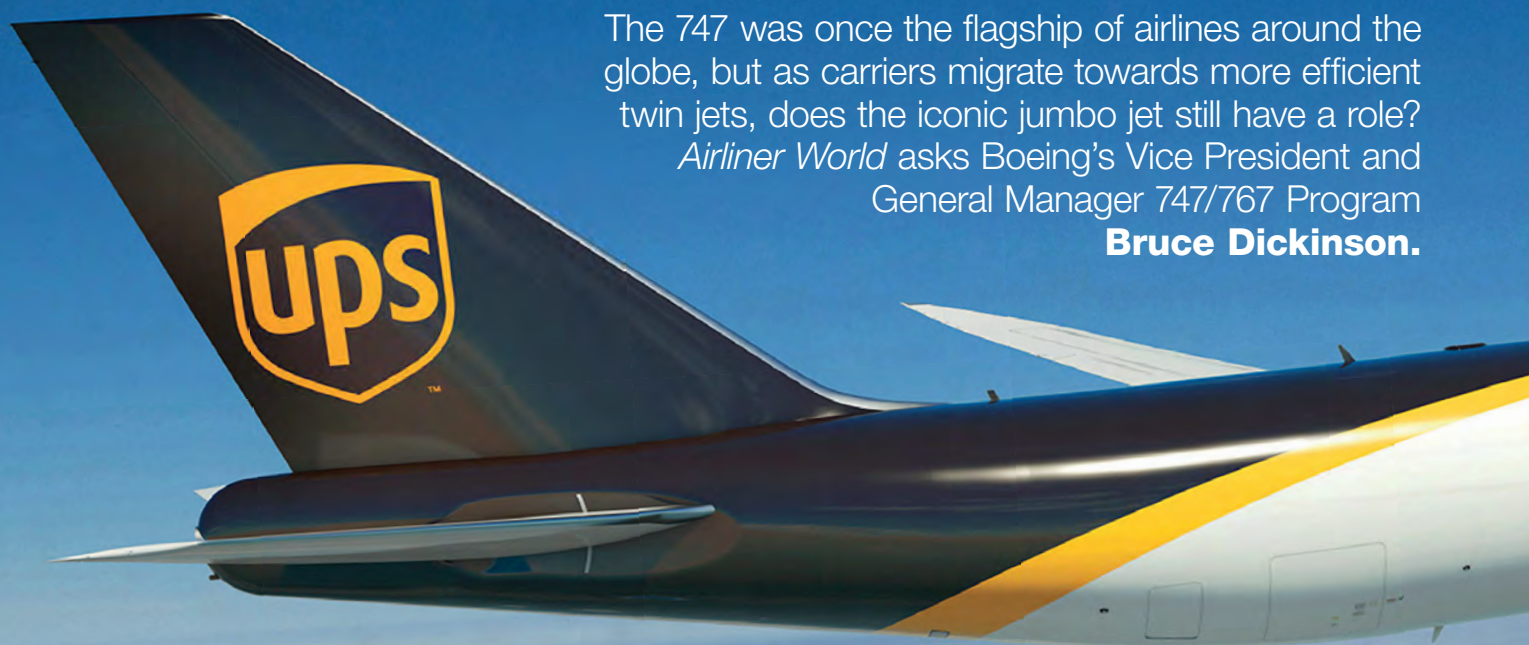
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The 747 was once the flagship of airlines around the globe, but as carriers migrate towards more efficient twin jets, does the iconic jumbo jet still have a role?

*Airliner World* asks Boeing's Vice President and General Manager 747/767 Program  
**Bruce Dickinson.**

# More than

**AW:** As we head towards the 50th anniversary of the 747, what do you think are the key achievements of the type?

**BD:** The 747 ushered in the jet age for real. It changed the way the world travelled, and it changed the face of airlines and their ability to deliver new markets. The aircraft also created opportunities for people and economies unlike anything that had come before it – there is no other aeroplane like it.

The exciting thing for me and my team is that the aircraft remains as relevant and as valuable today as when it first rolled out, if not more so.

We continue to invest in the aeroplane – the 747-8 has a new wing and engine, incorporating the very latest technology. With the latest variant, we've changed what matters to airlines most – the performance – while retaining the features that everyone loves about the 747, such as the spacious interior and the exclusive first-class experience in the nose of the aircraft that isn't interrupted by stairs like on other designs.

And then there's the private-jet feel of the upper deck. We have a long history with the latter in particular – on the -8 we extended and improved this further, drawing from the best interior features of the 787 Dreamliner.

Since the 747-8 entered service in

*Dickinson is confident the 747-8 will see a resurgence in the air freight market, with Boeing forecasting the need for up to 550 new large cargo aircraft over the next 20 years.*

*Bruce Dickinson has headed up the 747 programme since 2014.*

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2011, we've improved fuel efficiency by 3.5%, decreased operating costs by 2% and have shed almost 10,000lb [4,536kg] from the airframe weight, meaning more capacity, payload and better performance for operators. It's been great to have taken an iconic type and modernised it, keeping the elements that people love while gaining new features and performance improvements.

The new wing uses the latest

computational fluid dynamics 'tricks' to get the best efficiency, and we incorporated the very latest engine technology – the GE Aviation GENx is essentially the same as that used on the 787.

We also took a lot of the Dreamliner cabin features and put this into the passenger-carrying 747-8.

It's an aeroplane that has an iconic history, but continues to amaze passengers, airlines and cargo carriers even today.

**AW:** The 747-8 has been subject to a continuous improvement programme since it was rolled out. What changes have been made, and what impact have these had?

**BD:** We have been working solidly since the 747-8 entered service, just like any other new aircraft programme, to tweak and improve the aeroplane to improve efficiency. The huge reduction in airframe weight is part of this, but we've also made aerodynamic tweaks, such as how the elevators fair (streamlining the joint to the tailplane to reduce drag) and further optimising the wing.

We've improved fuel efficiency by 3.5% since the aircraft began entering service in 2011, and we've achieved a 2% reduction in operating cost – this is a big deal for our customers.

Away from physical changes to the





# an Aircraft

aeroplane, we have also continued to invest on improving on-time performance. We are well over our target of 99% dispatch reliability [the percentage of departures that leave within 15 minutes of the scheduled time] – we're currently running at around 99.3%, which is better than any other model of 747, and have been for well over a year now.

This has been achieved through increased reliability of the aircraft systems, which has reduced the number of error messages displayed to the air-

**BELOW RIGHT • The 747-8F freighter offers several advantages over the 777F, including a large nose-door, ability to carry outsized cargo and better hot-and-high performance over the twin-engined jet.**

**Boeing reduced 747 production from 1.3 aircraft per month to 0.5 last September.**

crew that may delay pushback for departure. And we've completely addressed any technical issues that came up following the initial entry into service.

**AW:** In September 2016 Boeing adjusted the production rate for the 747-8 from 1.3 aircraft per month to 0.5. What challenges has this brought?

**BD:** Decreasing the production rate is not something we like to do with any of our programmes, but it was necessary on the 747 to match supply with near-

term demand in the cargo market. However, rather than a straight reduction, we went for a more creative approach. We integrated our 747 and 767 lines, two of our lower-rate production systems, and combined them into a single programme.

This means we can maximise our skills and expertise across two different aeroplanes. More significantly, we have kept our employment levels steady – the reduction in 747 output has been offset by an increase on the 767, now 2 per >>





month and planned to grow again to 2.5.

It's been a great marriage of programmes. A lot of the manufacturing techniques, particularly on the fuselage, are very similar so there are a lot of synergies between the 747 and 767. We've also consolidated work areas such as empennage and systems installation so we can better utilise factory space, and we have the flexibility to move people back and forth between the two lines as demand dictates.

This really helps us – reducing output to six 747s a year means production is carried out across a far longer cycle, but being able to transfer staff to similar job roles on the 767 line means we could retain a lot of our highly skilled 747 workforce.

**AW:** Boeing has suggested a lot of existing 747-400 freighter operators will be looking to upgrade their fleets over the next two decades. What impact do you expect this to have on the 747-8F's long-term prospects?

**BD:** Our 20-year market forecast [released last October and predicting a 70% increase in the world air cargo fleet] estimated the need for 550 new large freighters. We may potentially see the emergence of an Airbus A350 freighter but, for the foreseeable future, the two biggest players in this segment – the 747-8F and the 777F – reside here in Everett.

It's a lot of aeroplanes, but it's not grossly different from the large freighter fleet in service today – around 550 aircraft, of which more than 200 are 747-400Fs (plus two dozen or so 747

Classics). Many of these aircraft will be retired over the next two decades.

And then there are well over 100 McDonnell Douglas MD-11s still flying but we know for certain they'll be withdrawn in the same timeframe – it's already happening today.

We've been waiting for this replacement market for some time. The air cargo market has faced challenges in recent years, but we're buoyed by the excellent fourth quarter (2016) results. Even based on nominal growth in the sector, there are a lot of large freighters that will retire over the next 20 years so we believe it's a significant market segment, and we're a major player with a unique product.

**AW:** Does this optimism carry across to the passenger variant?

**BD:** Given the existing market and the impending arrival of the 777X, it's clear that our long-term 747 production will be more freighter than passenger aircraft. The 747-8F has very different capabilities over the 777F, with a large nose door, ability to carry outsized cargo and better hot-and-high performance over a twin-engined jet.

But do I think there'll be interest in the passenger aircraft in the future? Absolutely, the 747 is still a unique aircraft that continues to attract interest.

**AW:** Does the increasing popularity of twin-engined widebodies spell the end of the quad-jet era?

**BD:** Absolutely not; I think we'll see the passenger market continue its migration towards big twins, but in


terms of freight, far less so. The 747-8F has unique capabilities that will be unrivalled for years to come. If you look at the reasons behind the UPS order [a \$5.3bn deal for 14 aircraft placed last October] the 747 is the right size for the markets the company operates in, and it's ideally suited to long-haul, high-volume freight routes.

I don't think it's the end of the four-engined airliner era, particularly in the cargo market, but I do see the big twins continuing to gain ground on the passenger side.

**AW:** Lastly, much has been written about the impact of the 747 on the commercial aviation industry, but what does the aircraft mean to Boeing today?

**BD:** A lot! We still call this aeroplane the Queen of the Skies here, and we know every operator around the world has its own favourite nickname and its own personal connection.

I get quite emotional when I reflect on the iconic nature of this aircraft. When airlines retire their 747s, there's always a lot of fanfare and invariably a lot more tears! I was part of Cathay Pacific's 747 farewell [last October] and gave a speech after the final flight – people were crying, and I even saw one person kiss the aircraft!

Our company still sees the aircraft as our flagship. We have a strong sense of history, and we still have that sense of wonder that came with the 747 – it's timeless in a lot of ways, and I think the whole company shares this attachment to the aeroplane. 

*Though it's almost five decades since the prototype 747 was rolled out, the type is still held in high regard by the manufacturer and its employees.*  
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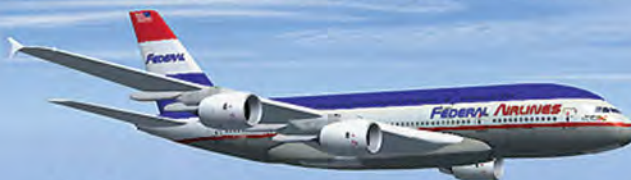
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There is little doubt the 747 was, quite literally, a huge gamble. The jet stood six storeys high and was 225ft-long, dwarfing its rivals and stablemates in both size and expense.

**Charles Kennedy** chronicles the development of Boeing's behemoth.

*Led by Joe Sutter, Boeing's 'Incredibles' designed and built the 747 prototype in just 29 months. Standing six storeys high and 225ft-long, the aircraft was unlike anything that has come before it.*

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# Planning a Giant



The 1960s was the first full decade of the Jet Age and the future path of commercial airliner evolution was unwritten. The British and French were pumping their resources into the joint development of the supersonic Aérospatiale/BAC Concorde, a sleek delta-wing design which would be capable of crossing the Atlantic in just three hours. The Americans adopted the 'bigger is better' mentality, focusing on economy of scale and efficiency. This led to the development of three widebody types. In California, McDonnell Douglas and Lockheed were designing their tri-jet DC-10 and L-1011 TriStar respectively, while up the west coast in Washington State, Boeing looked to salvage what it could from the failed CX-HLS (Cargo Experimental Heavy Logistics System) US military contract. This led to the creation of the biggest civil aircraft the world had ever seen – the 747.

### Throwing down the Gauntlet

Pan American World Airways (Pan Am) had arguably embraced the jet age more than any other carrier of the era, with a fleet of more than 75 707s (eventually swelling to almost 130) and a vast network spanning five conti-

nents. By 1965 the airline was predicting 35 million people would be flying international routes, a figure rising by 200% over the next 15 years. The need for a bigger aircraft was obvious, and Boeing agreed – it had been considering large airliner designs even before it lost the CX-HLS contract to Lockheed.

The decision to proceed came when Boeing President William M 'Bill' Allen and Pan Am founder and president >>

*The prototype Boeing 747, N7470 (c/n 20235) RA001, seen during its official roll-out at Everett, Washington on September 30, 1968.*



*The then Boeing President Bill Allen (left) and Pan Am founder and President Juan Trippe pose in front of the prototype 747.*



*The jumbo jet made its first flight on February 9, 1969, kicking off a ten-month certification programme.*







“The manufacturer repurposed the distinctive spiral staircase that had led down to the bar of the Model 377 Stratocruiser, and an icon of the 1970s was born.”

*The 747-100 encountered a string of issues with its Pratt & Whitney JT9D-3 engines and was widely considered to be overweight and underpowered.*

Juan T Trippe threw down the gauntlet to one another during a fishing trip. Talking of a new supersized people mover, Trippe promised: “If you build it, we’ll buy it,” to which Allen replied “If you buy it, we’ll build it.”

Responsibility fell to Boeing executive Malcom T Stamper, who was named as the president and general manager of the newly formed 747 Division. He went on to become the firm’s longest-serving president and, in 1978, became one of the first executives in the US to be paid more than \$1m a year. Stamper in turn appointed Joseph ‘Joe’ Sutter as project manager of the design team.

### **Dual Purpose**

Boeing considered a variety of configurations for its new jet, including a double-decker 707 and a side-by-side double-bubble fuselage. Airlines were generally negative about what were essentially improvised solutions, and Boeing also had to consider compatibility with the airfreight industry. At that time, it was widely assumed the future of passenger air travel would be supersonic. The company was investing heavily in its Mach 3 swing-wing model 2707 and the expectation was the 747 would serve largely as a freighter.

Designers eventually placed two main-deck cargo containers side-by-side and drew a circle around them, creating the circumference of the fuselage. The cockpit was moved up to a bubble above the main deck, making more room for freight, with space behind for avionics and crew rest. Trippe once again intervened, visiting Boeing’s plywood mock-up in March 1966 and marking out the upper deck for a cocktail lounge. The manufacturer repurposed the distinctive spiral staircase that had led down to the bar of the Model 377 Stratocruiser, and an icon of the 1970s was born.

### **The Incredibles**

Boeing needed a plant to build the massive 747 and surveyed 50 locations around the country. It took up an option to buy a 780-acre (315 ha) site next to the military base at Paine Field, near Everett in Washington State in June 1966. Construction was an enormous undertaking. More than 1 billion cu ft (28.3 million m<sup>3</sup>) of earth was moved and a new railway spur added to transport the 34,000 tons of structural steel required to build the plant. Work was hampered by a record-breaking 67 straight days of rain, which brought flooding and mudslides and added \$5m to the cost.

Inside the new facility, which remains the biggest building in the world by volume, assembly of the full-size 747 mock-up continued at a far quicker rate and was completed before the factory roof above it.

By May 1967 much of the major tooling had been installed and





*Lacking an assembly line big enough for the 747, Boeing was forced to construct a dedicated facility at Everett. The hangar, which is more than a mile long and has its own microclimate, remains the biggest in the world by volume.*

## Overweight and Underpowered

The 747 was initially designed to a maximum take-off weight (MTOW) of 680,000lb (308,442kg), but this was soon raised to 710,000 lbs (322,050kg). As the prototype neared completion, Boeing grew increasingly concerned about the aircraft's weight that continued to creep upwards, threatening to exceed the 2% margin permitted under the contract with Pan Am. The carrier calculated that every 1,000 lbs (454kg) of extra structural weight would cost \$5,000 per aircraft per year in lost payload.

The increased MTOW also led to problems for engine supplier Pratt & Whitney (P&W). Its JT9D, a cutting-edge powerplant, was designed to produce 41,000lb of thrust but would now need to generate an additional 1,000lb to propel the heavier 747 into the air.

This was the least of the engine manufacturer's worries. The first JT9D was test-run in early December 1966 at P&W's facility in East Hartford, Connecticut. Then a B-52 bomber was appropriated as a flying test bed with a single JT9D installed in place of its usual pair of J57s. The most serious shortcoming was that the 46 blades of the first-stage fan were rubbing against the bottom of the engine casing, while the casing itself was warping from a perfect circle to oval-shaped at high power settings in flight. This led to power surges and explosive compressor stalls.

Efforts to reduce the weight with broad strokes didn't get far. Switching the triple-slotted trailing edge flaps to double-slotted meant unacceptably high approach speeds; while making the two main body gears non-steerable saved 500lb (227kg) but required the use of asymmetric power during taxiing. So much in fact that >>



*In an effort to familiarise its 747 crews with the unusual sensation of sitting 29ft (8.8m) above the ground, Boeing created a mock-up cockpit mounted to a trailer. This rig, dubbed Waddell's Wagon after chief test pilot Jack Waddell, was then towed around the airfield.*

*BELOW • Pan Am – a real driving force behind the 747 programme – was launch customer for the type. It took delivery of its first example in December 1969. AIRTEAMIMAGES/ RALF MEYERMANN*

construction of the prototype 747 was launched. Parts and assemblies began arriving in August from subcontractors including Northrop (40 subassembly panels for the rear fuselage), North American (fibreglass/alloy wing leading edges), Fairchild-Hiller (leading and trailing edge flaps, control surfaces), and other Boeing facilities (wing spars and skin panels were produced at the manufacturer's factory in Auburn, 20

miles [32km] south of Everett). The young plane builders who were bringing the 747 dream into reality – contemporaries of the Apollo space workers and in the same league of engineering prowess and high energy – worked at such a pace and in such punishing conditions (the plant was still without a roof or heat) that they became known as The Incredibles.

**“If you build it, we’ll buy it...”**

Pan Am founder and president  
**Juan T Tripp**







*With its cockpit placed in a bubble above the main cabin and accessed via a distinctive spiral staircase, the nose area of the 747 was repurposed as a spacious and luxurious lounge.*

on one occasion the jet efflux blew a station wagon full of observers off a hardstanding and into a nearby field.

Smaller reductions were found elsewhere but this, and the lack of thrust from the first generation JT9Ds, meant early production 747-100s were overweight and underpowered.

Boeing's problems were just not confined to the aircraft. Development

costs of the wider 747 programme had risen so high that the then company president Thornton 'T' Wilson, who succeeded Bill Allen in April 1968, was forced to cut the workforce in its Commercial Aircraft Group from 83,700 to 20,750 by 1971, half of which were production workers. This was despite the manufacturer having secured orders for almost 200 aircraft

from 26 airlines.

Pan Am's new chairman Harold Gray gave the 747 another shot in the arm by converting eight purchase options into firm sales, upping the US carrier's commitment to 33 examples. It was a huge vote of confidence in the 'jumbo jet', and represented a significant investment from Pan Am, which also spent heavily to upgrade its Worldport terminal, and build a dedicated 747 maintenance facility, at New York/John F Kennedy.

### **Waddell's Wagon**

The prototype, N7470 (c/n 20235), was rolled out under soggy grey skies on September 30, 1968. The event opened with a performance of Sir Edward Elgar's Pomp and Circumstance by the Everett High School band, followed by half-an-hour of speeches before the hangar doors opened to reveal the giant 747, resplendent in a striking white and red livery and adorned with the logos of all 26 airline customers.

Once the aircraft had been towed clear of the hangar, flight attendants from each carrier were given rather vague instructions about exactly when they should crack their bottles of champagne against the side of the fuselage, resulting in a chaotic christening that was nonetheless good-spirited, while a three-ship formation of a 707, 727 and a 737 passed low overhead, skirting just under the cloud base.

Veteran test pilot Jack Waddell was chosen to lead the test flying







programme, with co-pilot Brien Wygle, who had just finished up his stint as chief test pilot on the 737 programme. Riding sideways at the flight engineer's station was Jesse Wallick.

The winter of 1968/69 was one of the worst in Washington State's history, with driving winds and snow squalls making work almost unbearable at Paine Field where the first flight was due to take place. Connie Smith, head of the pre-flight test unit, was reluctant to release the jet until issues with the JT9Ds had been resolved. Finally, in late January 1969, control of N7470 was passed to flight operations for taxi and high-speed ground runs.

Before the first flight, about 60,000lb (27,215kg) of test equipment was installed in the prototype, along with mailbags and a further 1,000lb (453.5kg) of water ballast carried in 55 US gal (208lit) aluminium beer kegs. This brought the take-off weight to 476,000lbs (215,909kg).

Initial testing of the JT9Ds had shown them to be extremely sensitive to wind effects which caused flame outs and compressor stalls. Waddell was understandably concerned. There was a risk of losing engine power at a critical phase of take-off and, potentially, having all four powerplants

*The 747-100 flight deck, with its Flight Engineer station, is a far cry from modern glass cockpits.*

*AIRTEAMIMAGES.COM/  
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“There was a risk of losing engine power at a critical phase of take-off and, potentially having all four powerplants doing so simultaneously.”

*OPPOSITE • Pan Am's inaugural 747 service, from New York/JFK to London/Heathrow on January 21, 1970 was beset by problems.*

*AIRTEAMIMAGES/  
CARL FORD*

doing so simultaneously. That would rob the 747 of thrust and hydraulic power needed to drive the flight controls. This led Sutter to instal a large bank of heavy-duty batteries as electrical back-up to keep the hydraulic system pressurised, even if all four engines failed.

Waddell also had reservations about landing an aircraft where the cockpit was 29ft (8.85m) above the ground. This led to a rather ingenious solution. Boeing created a mock-up flight deck, mounted on a rig at the same height as the 747. Dubbed 'Waddell's Wagon', this was towed around the airfield by a truck to familiarise the chief pilot and his colleagues with the unusual viewpoint.

### Airborne

Ground testing advanced well, and by early February 1969 Waddell had taken the 747 to the verge of take-off, accelerating to around 150mph (241km/h) before terminating the high-speed run.

Confident the aircraft was ready, Boeing settled on February 9 for its first flight. The day dawned grey and cloudy, but Waddell spoke by radio to the crew of a 707 airborne in the local area and ascertained the weather

was flyable.

Boeing chairman Allen joined the crew as they walked out to N7470 and told Waddell: "Jack, I hope you understand that the future of the company rides with you guys this morning." No pressure then...

The first engine was started at 11:09am and, a few minutes later, co-pilot Wygle called for taxi clearance. Waddell ordered the F-86 Sabre chase-plane into the air and, at 11:35am, the prototype 747 lined up for departure. The thrust levers were advanced to take-off power and, after a confirmation from Wallick that they had "four stable engines", Waddell released the brakes. After a ground roll of just 4,500ft (1,371m) the nose was hauled off the ground and, a second later, the Jumbo Jet was airborne and climbing away from Paine Field.

After reporting the aircraft was light on the controls and felt good, the chief pilot began a shallow bank to port, flying a 270° turn to pass overhead the airfield, giving assembled masses another opportunity to see Boeing's flagship before climbing to the west to begin testing in earnest.

After some gentle manoeuvring, the crew tried some of the fail-safes including shutting down two of the four independent hydraulic systems. The 747 responded exactly as

»





expected, and continued to fly on the remaining two systems with no noticeable loss of control. Asymmetric power settings were easily tuned out using the flight controls, and kicking the rudder pedal to induce a Dutch Roll (an out-of-phase combination of "tail-wagging" and rocking from side to side) had no effect.

One minor snag came as the flaps were extended from 25° to 30° and a loud thump was heard, quickly followed by some vibration. The flaps were immediately retracted to their previous setting and Wallick went back into the cabin to look for damage. The verdict was a loose section on the starboard side flaps.

Waddell wisely elected to terminate the sortie an hour earlier than planned and return to Everett, although not before a company 727 carrying Allen and members of the press briefly rendezvoused with the N7470 for some air-to-air photos. After a 1hr 16 min flight, the prototype 747 successfully completed its maiden sortie with a safe landing at Paine Field.

### Testing Times

N7470 returned to the air for the second time on February 15, after six days grounded for repairs to the flaps. During the 2hr 18min sortie Waddell successfully cycled the landing gear.

Allen flew in the jet for the first time on February 24 during a short transit across Seattle to Boeing Field where the remainder of the test programme was carried out.

Four days later, a second 747 and first production example, N747PA (c/n 19639) named *Clipper America*, was rolled out. The jet, destined to join Pan Am, completed its first flight on April 11 and was used to evaluate the type's propulsion, fuel, electro-mechanical and avionics systems.

**BELOW • The 747-100 series was operated by almost every major US carrier including United Airlines.**

AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION

**BOTTOM • The jumbo jet quickly established itself as the flagship for national carriers across the globe, including Avianca Airlines of Colombia.**

AIRTEAMIMAGES.COM/  
KEITH BLINCOW (AT)

A further three jets joined the certification programme: two more Pan Am examples N731PA (c/n 19637) *Clipper Bostonian* and N732PA (c/n 19638) *Clipper Storm King*, which tested function and reliability, and flight loads on the structure and surfaces, respectively. They were joined by TWA's first aircraft, N93101 (c/n 19667), which was responsible for aerodynamics, stability and control.

*Clipper Bostonian* quickly emerged as the most reliable airframe-powerplant combination, so this jet was chosen to make the 747's international debut at the 1969 Paris Air Show. The first

transatlantic crossing kicked off with a short hop to Seattle-Tacoma International Airport, which had a longer runway than Everett or Boeing Field. Here, the aircraft was fully fuelled before taking off on the 9hr 18min overnight crossing, arriving in Le Bourget on the morning of June 3 to a hero's welcome.

The jet suffered a minor technical snag on the return leg, when an overheating engine was shut down 140 miles (225km) from Seattle, but the 747 had proven to be eminently capable of long-haul operations.

The powerplant issue wasn't entirely







unexpected and reliability problems with the early JT9Ds blighted the test programme. In the period between February and December 1969, the 747 endured 87 engine breakdowns and 55 engine changes.

The only serious incident came on December 13, 1969 when N732PA was landing at Boeing's Renton facility to have its test equipment removed and replaced with an airline interior.

Facing a short, 5,280ft (1,609m) runway and a gusting crosswind, the pilot flew too low on the approach and the main gear struck an earth bank on the shore of Lake Washington around 20ft (6m) short of the threshold. The impact buckled parts of

the starboard landing gear and led to engines three and four being dragged along the tarmac in a shower of sparks and smoke. Repairs took six months.

This aside, the overall certification had been an incredible success, taking just ten months and throwing up no major surprises. Even with the early engine troubles, the enormous 747 had proven to be a stable aircraft,

dependable in all flight regimes from the outset. A truly incredible job by The Incredibles.

**The only serious incident to befall the programme came on December 13, 1969...**

### Into Service

With FAA approval secured, Pan Am began preparations for the 747's entry into service, but even this wasn't without drama. The


carrier, dismayed at continuing issues with the JT9Ds and a 7% shortfall in expected range, threatened to withhold \$4m from the final payment of each aircraft until the problems were rectified. A game of brinkmanship ensued, with Boeing at one stage threatening to sell the aircraft to rival carrier TWA.

Finally, a compromise was reached and on December 13, 1969 Pan Am took delivery of the first 747.

First Lady Pat Nixon christened the jet, N733PA (c/n 19640) *Clipper Young America* in a ceremony at Washington/Dulles on January 15, and the stage was set for its first revenue service.

The inaugural scheduled passenger flight on January 21, from New York/JFK to London Heathrow was beset with difficulties. After issues with doors and the cargo hold, Pan Am's New York chief pilot Robert Weeks and his crew ran into further problems when they tried to start the engines, which were overheating and backfiring due to the gusty wind on the icy tarmac.

The four powerplants were eventually stabilised at 7:29pm but, by the time *Clipper Young America* had taxied to the runway, engine number four had overheated again and Captain Weeks was forced to return to the terminal and unload the 336 passengers.

Eager to avoid a public relations disaster, Pan Am substituted in N736PA (c/n 19643) *Clipper Victor*, which had been delivered just a day earlier. Catering and baggage was transferred to the replacement aircraft and, at 1:50am, the inaugural 747 flight was finally under way, arriving in London 6hrs 16mins later. The age of the Jumbo Jet had arrived, and the world would never be the same. 

*Boeing 747-143 N606PE (c/n 19730), like many early 747s, enjoyed a long and varied history. It was delivered new to Alitalia in July 1970 and eventually flew with nine different carriers, including People Express Airlines, before being retired in 1990.*

AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION

*While the 747 is a commercial success, the type faced major challenges during its early years of operation. In the US, recession driven in part by the 1973 oil crisis changed the economic landscape, driving down passenger numbers and, in turn, forcing carriers such as Delta Air Lines to withdraw its jumbos in favour of smaller aircraft.*

AIRTEAMIMAGES.COM/  
CARL FORD





# An 'Incredible' Legend

There is little doubt the Boeing 747 has transformed the aviation industry. The iconic aircraft brought air travel to the masses and opened up affordable international flights that made the world significantly smaller. However, the 'Queen of the Skies' would not have been possible without the 'Incredibles', the highly skilled and motivated 50,000-strong workforce that took just 29 months to design and build the world's first widebody jet.

In charge of this band of construction workers, mechanics, engineers, secretaries and administrators was Joseph 'Joe' Sutter, a role that earned him the moniker 'the Father of the 747'.

## ***The Making of an Incredible***

Born on March 21, 1921, Sutter was the son of a Slovenian immigrant working in the Seattle meat-packing industry. His fascination with aviation started at an early age, and his aeronautical engineering course at the University of Washington was funded by a paper round and a part-time summer job on the Boeing assembly line.

Like many of his contemporaries, Joe was drafted into the armed forces after his graduation in 1943, serving on a US Navy destroyer in the Pacific. Demobbed three years later, Sutter initially accepted a job offer from Douglas Aircraft on the basis that, at \$210 a week, the Californian manufacturer was offering \$10 more than Boeing. However, with his wife Nancy pregnant and reluctant to move south, Joe took a short-term position with the Seattle-based firm in February 1946 – and he never left.

After initial attempts to improve the aerodynamics of the bulbous model 377 Stratocruiser, Boeing's last propeller-driven airliner, Sutter moved across to the company's first jet transport, the 367-80 (more commonly known as the 'Dash 80'). As his engineering prowess came to the fore, he was offered bigger and more important roles in Boeing's





growing jetliner family. This included developing an innovative wing glove modification for the 720B (an offshoot of the 707) that increased the critical Mach number and allowed the type to compete more effectively with the faster Convair CV-990.

Sutter was also closely associated with the later 727 tri-jet and particularly its sophisticated flap design. His work with Boeing designer Jack Steiner on the 737 saw him make the pivotal decision to place the engines beneath the wing "where they belonged" rather than on the rear fuselage as favoured by rival manufacturers. This led to the then standard \$50 payment for the patent on the 'Baby Boeing'.

Sutter will, however, be best remembered for leading the design of the 747 from 1965 onwards. Armed with draft configurations created by his engineering team, he visited a host of major carriers and was stunned when almost all of them voted for the largest design seating 350. "It was a sort of shock because the 707 carried 120 people and suddenly they wanted an airplane two-and-a-half times the size of it," he later recalled.

Resisting initial concepts of full-length double-deckers, which he described as "clumsy", Sutter instead pushed for the radical alternative of a very wide single deck with twin aisles – the first widebody.

Reflecting on the 747, Sutter told the BBC in 2015 that "it was a fight all the way". At the time, it represented a huge gamble for Boeing – the prototype 747 stood six storeys high with a fuselage measuring 225ft-long, dwarfing its

*Sutter joined Boeing in 1946 after leaving the US Navy, and went on to work on almost all of the manufacturer's jet-powered airliners. ALL PHOTOS BOEING*

*OPPOSITE • Sutter was dubbed 'The Father of the 747' for his role leading the 'Incredibles', the 50,000-strong band of construction workers, engineers, mechanics, secretaries and administrators that designed and produced the prototype jumbo jet in just 29 months.*

*After retiring in 1986, Sutter continued to work with Boeing as a consultant. He passed away on August 30, 2016 aged 95.*



rivals and stablemates in both size and expense. Development of the behemoth required the construction of the largest building in the world to house the new aircraft. It was also blighted by major cash flow problems – Sutter successfully staved off company demands to lay off 1,000 of his 4,500 engineers – and repeated difficulties with the Pratt & Whitney JT9D engines.

There was also the issue of perception. The 747 was a staunch act of defiance at a time when the industry was hell-bent on speed rather than size, and Boeing's desire to take on the Anglo-French Concorde initially left the jumbo as the poor relation to the Seattle manufacturer's Mach 3 model 2707 airliner. Ironically, the latter was finally abandoned in 1971, while the 747 set a benchmark by which all subsequent commercial aircraft programmes have been judged.

What this aircraft did for Boeing was remarkable. Ray Connor, Vice Chairman


of The Boeing Company reflected: "[Sutter] personified the ingenuity and passion for excellence that made Boeing airplanes synonymous with quality the world over." He added: "His team, along with thousands of other Boeing employees involved in the project, became known as the 'Incredibles' for producing what was then the world's largest airplane in record time – 29 months from conception to roll-out. It remains a staggering achievement and a testament to Joe's 'incredible' determination."

### Life After the Jumbo

After moving on from the 747 programme, Sutter remained with Boeing – first as vice president of operations and product development and later as executive vice president for engineering and product development – and was heavily involved in the 757 and 767.

In 1985, he received the National Medal of Technology and Innovation from President Ronald Reagan, before retiring from full-time work a year later after four decades at Boeing.

"Long after he retired, Joe remained very active within the company," Connor recalled. "He continued to serve as a consultant on the Commercial Airplanes Senior Advisory Group, and he was still a familiar sight to many of us working here. By then his hair was white and he moved a little slower, but he always had a twinkle in his eye, a sharp mind and an unwavering devotion to aerospace innovation and The Boeing Company... he was one of a kind."

Joseph 'Joe' Sutter passed away on August 30, 2016, aged 95. 





# Gone, But Not Forgotten

Introducing the Boeing 747 into commercial revenue service revolutionised air travel almost overnight. In the early 1970s the jumbo jet was the 'must have' airliner for many long-haul carriers, some of which are, sadly, no longer flying. This montage illustrates a few of the famous names that flew the early variants of the 747, opening up global travel for the 'common man' for the first time.

The second US airline to take delivery of a 747 was Trans World Airlines (TWA). One of the carrier's aircraft, N93109 (c/n 19675), is on final approach to London/Heathrow in January 1984.

AIRTEAMIMAGES.COM/  
BOB ROBINSON



The first 747-136, G-AWNA (c/n 19761), was delivered to British Overseas Airways Corporation (BOAC) on April 22, 1970 and flew for four years in the airline's iconic blue, white and gold livery. It and 17 other jets were transferred to the new British Airways after its formation on March 31, 1974.

AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION



Braniff International was a regular visitor to Gatwick in the late 1970s and early 1980s. Its distinctive bright orange livery earned its 747s various nicknames including 'The Great Pumpkin'.

AIRTEAMIMAGES.COM/  
CARL FORD







**Former People Express Airlines** 747-143, N603PE (c/n 19729) joined Continental Airlines after the carrier was acquired by Texas Air Corporation. It continued to operate for another 14 years with various carriers before being broken up in April 2001.  
AIRTEAMIMAGES.COM/  
RALF MEYERMANN



**Taxiing to the runway at Düsseldorf, Germany** is 747-129, OO-SGB (c/n 20402) of former Belgian flag carrier SABENA.  
AIRTEAMIMAGES.COM/  
WOLFGANG MENDORF



**Pan American World Airways (Pan Am)** became the first airline in the world to introduce the 747 into service on January 22, 1970. It operated the carrier's prestigious New York to London link.  
AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION



**The last of the initial batch of 747s delivered to Northwest Airlines** was this Series 100 aircraft, N610US (c/n 19787), seen here departing from Gatwick Airport in June 1983.  
AIRTEAMIMAGES.COM/  
CARL FORD



**CP Air, based in Vancouver, British Columbia, joined the 747 family in November 1973** when its first of four examples, 747-217B C-FDRA (c/n 20801), was handed over. The jets were flown by the carrier until 1986 when they were sold to Pakistan International Airlines.  
AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION



# Defining the Design

**Charles Kennedy** continues to explore the evolution of the jumbo jet, looking at variants that have since been identified as belonging to the 'Classic' series.

**T**he 747-100 is a true classic – a design straight out of the 1960s, when not only was oil just \$3 a barrel (\$21 in today's money), it didn't move more than a few cents either way between 1948 and 1973 – an astonishing run of cheap energy and economic continuity for an industry that relies on both for its existence.

To be clear, the early 747s were incredibly efficient, representing a revolutionary change in productivity for its owners; but the very low price of fuel meant there was room for onboard enhancements such as the upper-deck cocktail lounge and nine-abreast seating in economy, which would easily compete, in both seat width and legroom, with today's Premium Economy products.

It hadn't occurred to the industry that it was possible to provide air travel without that kind of style and comfort although, ironically, it was the 747 that demonstrated to the airlines how much money they could make through economies of scale.


## Into Service

After Pan American World Airways (Pan Am) inaugurated 747 services on January 22, 1970, Trans World Airlines (TWA) and American Airlines followed suit in March, operating their jumbo jets on the New York to Los Angeles domestic rotations. Lufthansa meanwhile put its first 747

*The unmistakable shape of the Boeing 747 has been seen at airports worldwide for almost five decades.*

AIRTEAMIMAGES.COM/  
ALEX FILIPPOPOULOS





on the Frankfurt to New York route, becoming the type's first foreign operator. Later that year Japan Air Lines and Northwest Orient introduced theirs on domestic and transpacific links.

As the first deliveries to UK long-haul flag carrier British Overseas Airways Corporation (BOAC) loomed, a pay dispute saw pilots refusing to start their 747 conversion training until the issue was settled. Its first jumbo jet, G-AWNA (c/n 19761) – the 23rd built – flew into London/Heathrow on April 22, 1970, followed by 'NB' on May 6 and 'NC' 22 days later.

But they remained parked while negotiations rumbled on.

“...the very low price of fuel meant there was room for onboard enhancements such as the upper-deck cocktail lounge and nine-abreast seating in economy...”

### Teething troubles

The dispute saved BOAC a considerable headache, as the early Pratt & Whitney JT9D engines on the 747-100 proved extremely unreliable in service. The inaugural Pan Am flight to London had been delayed by engine problems that eventually necessitated a change of aircraft.

In addition to regular episodes of overheating – and to passengers' horror – there were also explosive compressor stalls which, while not particularly dangerous, manifested themselves with unnerving bangs and flames shooting out of the exhaust, leading to countless cancelled flights.

BOAC bypassed the issue while its labour problems were ironed out, even leasing some of its own stocks of the troubled engine to other operators who desperately needed them >>





One of the rare occasions you'll see a Boeing aircraft painted with 'Airbus' titles. The 747SR demonstrator was marketed as the '747 Super Airbus'.  
KEY COLLECTION

as their own spares rapidly diminished. Not until early 1971, with pilots and cabin crew contracts settled and nominated staff reporting for training on March 1, did BOAC's 747s finally begin passenger services from the UK – with the inaugural flight, on April 25, heading to New York/JFK, followed by other early destinations such as Montreal and Bermuda.

Most US domestic carriers were early 747 customers, but a spike in fuel prices soon after deliveries started made the aircraft unsuitable for short-haul

flights. Continental Airlines had four but sold them to Iran in 1975; National Airlines had two, selling them to Northwest in 1976; and Delta Air Lines sold its five to Flying Tigers in 1977.

Braniff International – famous for painting its aircraft in different colours – fared better with a solitary 747: nicknamed the *Big Orange* because of its unmistakable livery, it flew a daily rotation

from Dallas to Honolulu from its 1970 delivery right up to the airline's bankruptcy in 1982.

Meanwhile, American Airlines operated a handful of passenger and freighter aircraft and managed

to keep the type gainfully employed (including a starring role for N9675 (c/n 20390) in the film *Airport 1975*) up to the mid-1980s when UPS bought the last four. United did much

“ [United's] 747s were unique among US legacy carriers by staying with their original owner for their entire flying careers. ”

More Classic 747s are put together at the Boeing plant at Everett, Washington State.  
KEY COLLECTION



Pan Am was the first operator of the Boeing 747.  
AIRTEAMIMAGES.COM/  
WOLFGANG MENDORF





**Boeing's maiden 747 sits on the ramp alongside the first SP at the latter's roll-out in 1975.**  
KEY COLLECTION



**This TWA example, N93119 (c/n 20083), crashed into the sea off Long Island, New York, in July 1996.**  
AIRTEAMIMAGES.COM/  
CARL FORD



**Lufthansa has been a keen supporter of the jumbo, taking delivery of its first 747-100, D-ABYA (c/n 19746), in March 1970.**  
KEY COLLECTION



better with its eighteen 747-122s, flying hourly on trunk routes across the US, connecting New York with Los Angeles and San Francisco. It was also the market leader for seats to Hawaii, and deployed peak-hour jumbo services on other busy domestic services including Chicago to Los Angeles.

The airline's 747s were unique among US legacy carriers by staying with their original owner for their entire flying careers.

Pan Am was more than the launch customer: it was the catalyst for the 747. But, like many pioneers, it didn't flourish the way its successors did. In all, its 33 jumbo jets were a lot to swallow, even for the world's most experienced airline – especially with the price of oil tripling in 1973 alone, which didn't just make flying more expensive, it also hurt demand as high gasoline and heating prices soaked up its customers' discretionary income.

The carrier couldn't fail on the big routes such as London to New York, or Tokyo to San Francisco and, notably, it put the 747 on its prestigious round-the-world flights, PA001 (San Francisco to New York via Tokyo, Hong Kong, Bangkok, Delhi, Tehran, Beirut, Istanbul, Frankfurt and London) and PA002 (the reverse service), with full traffic rights between all destinations.

The sharp-eyed reader will have spotted the continental gap precluding that from being a true round-the-world flight: Pan Am still didn't have domestic traffic rights within the US, and the lack of domestic feed to its international gateways made its jets hard to fill.

That vast route network, however, became a burden to Pan Am's 747s which, while being the first in airline service, then became the oldest: other operators acquired later generations of the type, benefiting from design improvements and better efficiency, but Pan Am did not follow suit.

The pioneering -100 still had a bit of life left in it, and in September 1977 Boeing announced a new 747 variant, known as the -100B, with a reinforced structure and uprated engines. Iran Air ordered four, but, due to the Iranian Revolution in 1979, only one was delivered. Elsewhere, eight examples ordered by Saudi Arabian flag carrier Saudia became the only Rolls-Royce powered 747-100s built.

Another version developed for Japanese carriers, the 747SR (Short Range also known as the 747D for Domestic), featured a stronger structure, landing gear and brakes for operating high-cycle flights in Japan's domestic market. It had a lower fuel capacity but a greater payload, allowing for an all-Economy seating configuration for up to 498 passengers.

When production of the -100 came to an end, Boeing had delivered 167 to airlines worldwide. >>





### Enter the -200

An upgraded 747, announced in 1967, boasted modifications throughout – tougher landing gear, new flap actuators, thicker wing skin, stronger spars and other structural enhancements.

More powerful JT9Ds were coming on line as Pratt & Whitney got to grips with its huge turbofan engine. Meanwhile, both General Electric and Rolls-Royce were coming up with competing powerplants – the CF6 (which would also power the McDonnell Douglas DC-10 and Airbus A300/310); and the British manufacturer's RB.211, used on the Lockheed L-1011 TriStar and offered as an option on the later 767s. All three engine types were offered to customers of the new 747B, later renamed the 747-200B.

Built for Northwest Orient, the first

747-200B, N611US (c/n 20356), the 88th jumbo jet built, rolled out of Boeing's Everett plant on September 30, 1970 and took to the air for the first time on October 11.

It then headed to Edwards Air Force Base, California, for flight testing, which included setting a new world record for a maximum take-off weight of 820,700lb (372,263kg), beating the previous record set by a US Air Force Lockheed C-5A Galaxy by ten tonnes.

The first 747-200B to enter airline service, PH-BUA (c/n 19922) *Mississippi*, made its debut with KLM in February 1971. Northwest followed with the new variant a month later.

BELOW LEFT • *British Caledonian Airways' 747-2D3B G-CITB taxis at Gatwick Airport.*

AIRTEAMIMAGES.COM/  
CARL FORD

BELOW RIGHT • *The Queen of the Skies opened up air travel to the masses.*

AIRTEAMIMAGES.COM/  
GABRIEL SAVIT

Other carriers couldn't get enough of them, especially in Asia, with Japan Airlines operating nearly fifty 747 Classics...

Originally, the -200Bs were fitted with three windows in the upper deck, but the increased maximum take-off weight allowed for additional payload, so the upper deck was stretched internally by 6ft (1.9m) to 26ft (7.62m). This created space for seven more windows, as well as conventional airline seating to make a Business Class cabin of 16, usually in four rows of recliners. The days of the cocktail lounge were now numbered.

The first 747-200B with the internally stretched upper deck – Australian flag carrier Qantas' debut jumbo jet, VH-EBA (c/n 20009) *City of Canberra*, delivered in July 1971 – was also the first Boeing widebody with a galley in the belly, reached by an internal lift from the main deck.

While some countries operated single 747s as national flagships,







*The upper deck on the -300 variant is 23ft 4in longer than its predecessor.*

AIRTEAMIMAGES.COM/  
BOB ROBINSON

OPPOSITE • The sun sets on the flight deck of Pullmantur Air Boeing 747-341 EC-100 (c/n 24106) as it makes its way across the Atlantic. AIRTEAMIMAGES.COM/ ISMAEL JORDA



triumph for the operators and for the financial wellbeing of their nations.

Three 747-2B4B side cargo door variants (SCDs) were delivered to Lebanese national carrier Middle East Airlines (MEA) in 1975, just as the country descended into a civil war lasting 15 years. The SCDs could fly passengers, cargo or a combination of both, and commanded high lease rates for MEA which used the hard currency earnings to cover its payroll during the long conflict.

These 747s served in the liveries of Gulf Air, EgyptAir, Saudia, Nigeria Airways, Air France, Garuda and British Airways among others, often in pairs. At the end of the war in 1990 they returned to MEA service and spent the rest of the decade finally connecting Beirut to the world, 15 years later than intended.

The only 747-200 to receive British Airways' current Chatham Historic Dockyard livery was G-BDXB (c/n 21239), as the Classics were coming up to retirement with BA and most other airlines.

*American Airlines' 747-123 N9674 is pushed off stand ready for departure at Gatwick.*

AIRTEAMIMAGES.COM/  
KEITH BLINCOW (AT)

carriers such as Air Gabon, Air Madagascar and Cameroon Airlines used the type to provide vital diplomatic and trade links with the rest of the world.

Other carriers couldn't get enough of them, especially in Asia, with Japan Airlines operating nearly fifty 747 Classics (including 12 freighters); All

Nippon Airways (ANA), which in those days had no international traffic rights outside Japan, had 17 just to compete on domestic routes.

In Europe, British Airways had 19 -136s and 23 -236Bs, and Lufthansa five -130s and 22 -230Bs (12 with main deck side cargo doors fitted). The two fleets flew to six continents daily, a

*Qantas' 747-200Bs were the first with an internally stretched upper deck.*

AIRTEAMIMAGES.COM/  
BOB ROBINSON

>>







The first to leave the fleet was BOAC's first 747-136, G-AWNA, which retired in November 1998 at nearly 30 years old. To mark the occasion, the jet was painted in a basic BOAC livery for its final weeks of service before being ferried to Bruntingthorpe, Leicestershire and later scrapped.

The last Classic to leave the fleet was a -236, which flew from Bombay to London on the last day of October 2001, its retirement plans hastened by the post-9/11 downturn in air traffic.

Today only a handful of 747-200 freighters are still flying, but all passenger variants have retired – from a total of 393 built by Boeing.

**Improved design**

Airline demand for aircraft with an even longer range and a higher payload saw Boeing engineers develop an improved variant of the jumbo jet by stretching the upper deck – leading to the launch of the 747-300 in a programme initiated following an order for five from Swissair.

The prototype made its inaugural flight on October 5, 1982, with the first production jet delivered to Swissair on March 23, 1983. Deliveries to other carriers including Qantas and Cathay Pacific Airways soon followed.

Compared to the -200, the -300's upper deck was stretched aft by 23ft 4in (7.11m), increasing Economy Class seating from 32 to a maximum of 69. The extension called for the addition of two new emergency exit doors for the upstairs cabin, while an optional flight crew rest area behind the cockpit could

*Air Atlanta Icelandic has been a keen operator of classic jumbos over the years.*

AVIATION IMAGE NETWORK/  
BAILEY

*MASKargo Boeing 747-236B 9M-MHI stands out against a brilliant blue sky.*

AVIATION IMAGE NETWORK/  
BAILEY



*Boeing 747-367 AP-BFY (c/n 23920) smokes the mains on landing at Manchester.*

AVIATION IMAGE NETWORK/  
BAOLUO





also be fitted.

Boeing also introduced a new straight stairway to the upper deck, replacing the spiral version used on earlier variants, creating additional room above and below for more seating.

Otherwise the aircraft remained essentially similar to the -200; there were some minor aerodynamic changes, but the jet's maximum take-off weight and engine options remained the same – although General Electric had updated its CF6 engines.

Variants of the -300 developed by Boeing included the 747-300M Combi (featuring a cargo area at the rear of the main deck) and the short-range -300SR, built specifically for Japan Air Lines for its high-density domestic services, seating a maximum of 584 passengers. The manufacturer also offered the stretched upper deck as a retrofit for -100/-200 models, two carriers, KLM Royal Dutch Airlines and Union de Transports Aériens (UTA), modifying some of their earlier -200s.

Boeing didn't develop a production freighter variant of the -300, but started offering passenger-to-freighter conversions in 2000.

When airlines became aware of the



**Surinam Airways operated 747-306 PZ-TCM (c/n 23508) from 2004 until 2010.**

AVIATION IMAGE NETWORK/  
SIMON GREGORY

**The imposing sight of a Korean Air Cargo 747-230B on short finals to Heathrow.**

AIRTEAMIMAGES.COM/  
PHILIPPE NORET

prospect of another new variant, the -400, there was a dramatic effect on sales, with most carriers prepared to wait; indeed, the -300 was not ordered by a single North American carrier. But it's still impressive that Boeing achieved orders for 81, including 21 -300M and four -300D domestic models for the Japanese market.

In 1985, just two years after the

variant had first entered service, production was superseded by the 747-400. The last -300, OO-SGD (c/n 24837), went to former Belgian national carrier Sabena in September 1990. The airframe featured several aerodynamic refinements – particularly evident around the wing-to-body join area – under development for use on the new -400 variant. **✈️**

“Boeing also introduced a new straight stairway to the upper deck, replacing the spiral version used on earlier variants...”





# BOEING 747-400 CUTAWAY

1. Radome
2. Weather radar scanner
3. Front pressure bulkhead
4. Scanner tracking mechanism
5. Wardrobe
6. First class cabin, 30 or 34 seats at 62in (1.57m) pitch
7. Nose undercarriage wheel bay
8. Nosewheel doors
9. Twin nosewheels
10. Hydraulic steering jacks
11. Nose undercarriage pivot fixing
12. Underfloor avionics equipment racks
13. Cabin window panels
14. First Class bar unit
15. Flight deck floor level
16. Rudder pedals
17. Control column
18. Instrument panel, five-CRT electronic flight instrumentation system (EFIS)
19. Instrument panel shroud
20. Windscreen panels
21. Overhead systems switch panel
22. First officer's seat
23. Captain's seat (two-crew cockpit)
24. Observer's folding seats (two)
25. Starboard side toilet compartments (two)
26. Cockpit bulkhead
27. Crew rest bunks (two)
28. Upper deck window panel
29. Conditioned air distribution ducting
30. Forward main deck galley unit
31. Plug-type forward cabin door, No 1 port and starboard
32. Business Class passenger seating, 24 seats typical at 36in (91cm) pitch
33. Fuselage lower lobe skin
34. Baggage/cargo pallet containers
35. Forward underfloor cargo hold, capacity 2,768 cu ft (78.4m<sup>3</sup>)
36. Forward fuselage frame and stringer construction
37. Upper deck doorway, port and starboard
38. Cabin roof frames
39. Anti-collision light
40. No 1 UHF communications

47. Ventral air conditioning packs, port and starboard
48. Wing spar bulkhead
49. Economy Class seating
50. Staircase to upper deck
51. Fresh water tanks
52. Wing centre-section fuel tankage, capacity 16,990 US gal (64,315 lit)
53. Centre-section stringer construction
54. Floor beam construction
55. Front spar/fuselage main frame
56. Upper deck lobby area
57. Curtained bulkhead
58. Galley Units
59. Starboard wing inboard main fuel tank, capacity 12,546 US gal (47,492 lit)
60. Fuel pumps
61. Engine bleed air supply ducting
62. Krüger flap opening mechanism

80. Starboard winglet
81. Fixed portion of trailing edge
82. Fuel vent
83. Static dischargers
84. Outboard, low-speed, aileron
85. Outboard four-segment spoilers
86. Outboard triple-slotted Fowler-type flap, down position
87. Flap screw jacks and segment linkages
88. Flap drive shaft
89. Inboard, high-speed, aileron
90. Inboard triple-slotted flap, down position
91. Inboard two-segment spoilers/lift dumpers
92. Flap screw jack
93. Auxiliary trailing-edge wing spar
94. Cabin air distribution ducting
95. Extended upper deck floor beam construction
96. Upper deck floor beam construction
97. Air system cross-feed ducting
98. Conditioned air risers
99. Machined wing spar attachment main frames

41. Upper deck passenger cabin, 52 Business Class seats or 69 Economy Class seats
42. Lower deck sidewall toilet compartment
43. No 2 passenger door, port and starboard
44. Air-conditioning system heat exchanger intake ducting
45. Ventral flush air intakes
46. Faired wing root leading-edge fillet

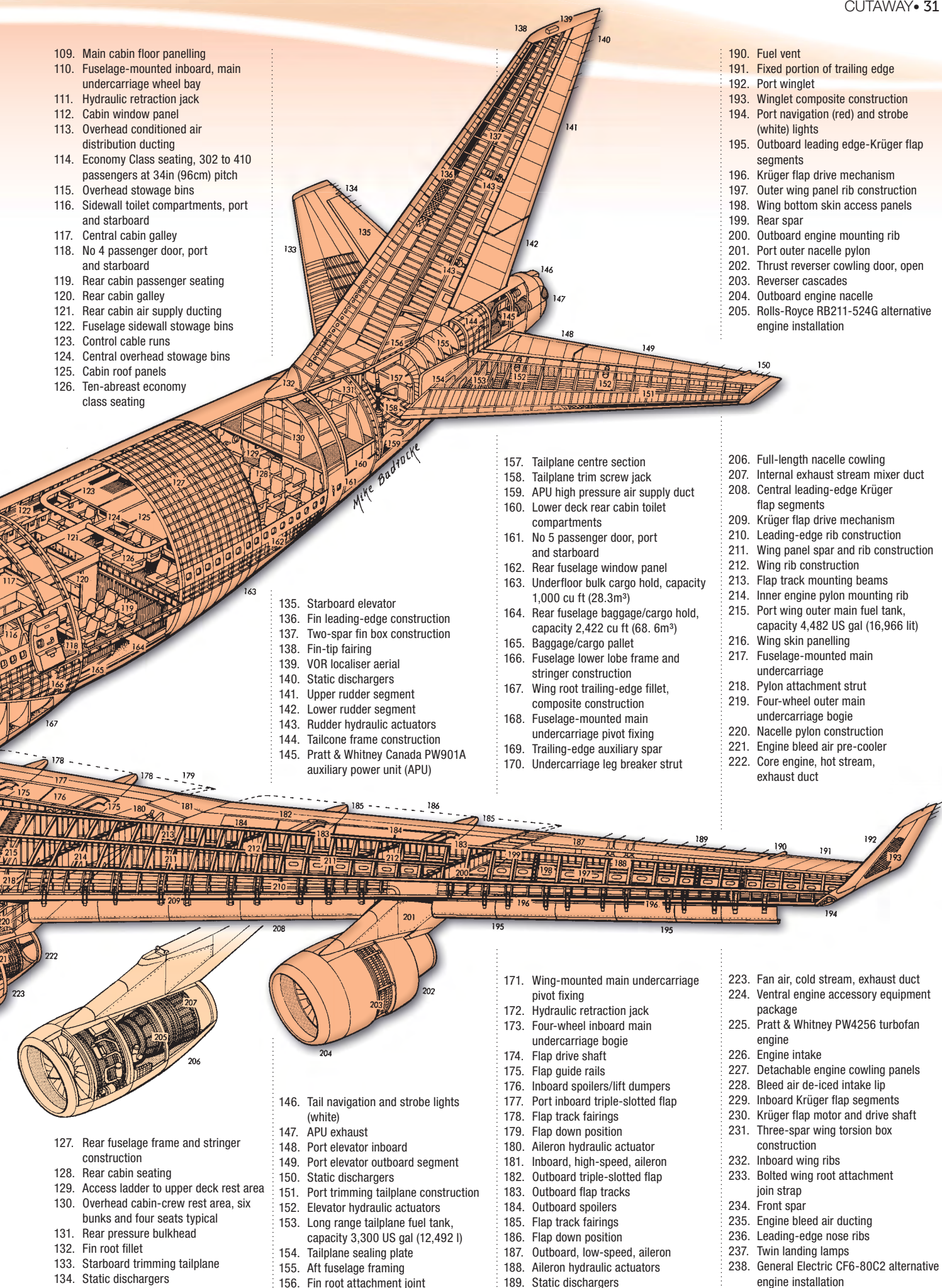
63. Inboard Krüger flap segments
64. Starboard inner Pratt & Whitney PW4256 engine nacelle
65. Inboard nacelle pylon
66. Leading-edge Krüger flap segments
67. Pressure refuelling connections, port and starboard
68. Krüger flap drive shaft
69. Krüger flap rotary actuators
70. Starboard wing outer main fuel tank, capacity 4,482 US gal (16,966 lit)

71. Starboard outer engine nacelle
72. Outer nacelle pylon
73. Starboard wing reserve tank provision, capacity 534 US gal (2,021 lit)
74. Outboard Krüger flap
75. Krüger flap drive mechanism
76. Outer wing panel dry bay
77. Vent surge tank
78. Wing-tip extension
79. Starboard navigation (green) and strobe (white) lights

100. Central flap drive motors
101. Wing-mounted outboard main undercarriage wheel bay
102. Undercarriage mounting beam
103. Central keel section
104. Pressure floor above wheel bay
105. Centre fuselage frame and stringer construction
106. Dual navigation aerals
107. Cabin wall trim panelling
108. Seat mounting rails







109. Main cabin floor panelling
110. Fuselage-mounted inboard, main undercarriage wheel bay
111. Hydraulic retraction jack
112. Cabin window panel
113. Overhead conditioned air distribution ducting
114. Economy Class seating, 302 to 410 passengers at 34in (96cm) pitch
115. Overhead storage bins
116. Sidewall toilet compartments, port and starboard
117. Central cabin galley
118. No 4 passenger door, port and starboard
119. Rear cabin passenger seating
120. Rear cabin galley
121. Rear cabin air supply ducting
122. Fuselage sidewall storage bins
123. Control cable runs
124. Central overhead storage bins
125. Cabin roof panels
126. Ten-abreast economy class seating

190. Fuel vent
191. Fixed portion of trailing edge
192. Port winglet
193. Winglet composite construction
194. Port navigation (red) and strobe (white) lights
195. Outboard leading edge-Krüger flap segments
196. Krüger flap drive mechanism
197. Outer wing panel rib construction
198. Wing bottom skin access panels
199. Rear spar
200. Outboard engine mounting rib
201. Port outer nacelle pylon
202. Thrust reverser cowling door, open
203. Reverser cascades
204. Outboard engine nacelle
205. Rolls-Royce RB211-524G alternative engine installation

135. Starboard elevator
136. Fin leading-edge construction
137. Two-spar fin box construction
138. Fin-tip fairing
139. VOR localiser aerial
140. Static dischargers
141. Upper rudder segment
142. Lower rudder segment
143. Rudder hydraulic actuators
144. Tailcone frame construction
145. Pratt & Whitney Canada PW901A auxiliary power unit (APU)

157. Tailplane centre section
158. Tailplane trim screw jack
159. APU high pressure air supply duct
160. Lower deck rear cabin toilet compartments
161. No 5 passenger door, port and starboard
162. Rear fuselage window panel
163. Underfloor bulk cargo hold, capacity 1,000 cu ft (28.3m³)
164. Rear fuselage baggage/cargo hold, capacity 2,422 cu ft (68.6m³)
165. Baggage/cargo pallet
166. Fuselage lower lobe frame and stringer construction
167. Wing root trailing-edge fillet, composite construction
168. Fuselage-mounted main undercarriage pivot fixing
169. Trailing-edge auxiliary spar
170. Undercarriage leg breaker strut

206. Full-length nacelle cowling
207. Internal exhaust stream mixer duct
208. Central leading-edge Krüger flap segments
209. Krüger flap drive mechanism
210. Leading-edge rib construction
211. Wing panel spar and rib construction
212. Wing rib construction
213. Flap track mounting beams
214. Inner engine pylon mounting rib
215. Port wing outer main fuel tank, capacity 4,482 US gal (16,966 lit)
216. Wing skin panelling
217. Fuselage-mounted main undercarriage
218. Pylon attachment strut
219. Four-wheel outer main undercarriage bogie
220. Nacelle pylon construction
221. Engine bleed air pre-cooler
222. Core engine, hot stream, exhaust duct

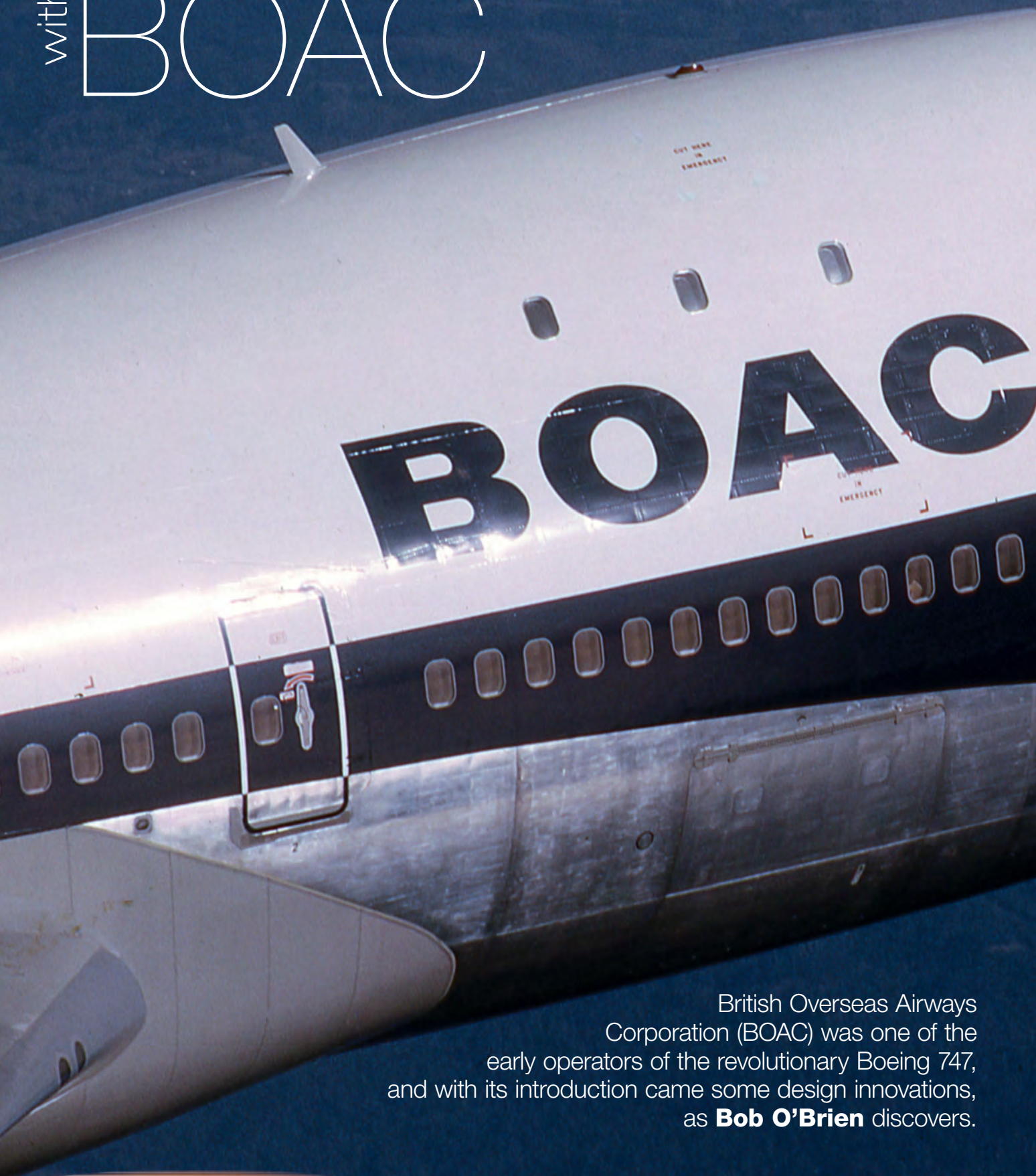
171. Wing-mounted main undercarriage pivot fixing
172. Hydraulic retraction jack
173. Four-wheel inboard main undercarriage bogie
174. Flap drive shaft
175. Flap guide rails
176. Inboard spoilers/lift dumpers
177. Port inboard triple-slotted flap
178. Flap track fairings
179. Flap down position
180. Aileron hydraulic actuator
181. Inboard, high-speed, aileron
182. Outboard triple-slotted flap
183. Outboard flap tracks
184. Outboard spoilers
185. Flap track fairings
186. Flap down position
187. Outboard, low-speed, aileron
188. Aileron hydraulic actuators
189. Static dischargers

223. Fan air, cold stream, exhaust duct
224. Ventral engine accessory equipment package
225. Pratt & Whitney PW4256 turbofan engine
226. Engine intake
227. Detachable engine cowling panels
228. Bleed air de-iced intake lip
229. Inboard Krüger flap segments
230. Krüger flap motor and drive shaft
231. Three-spar wing torsion box construction
232. Inboard wing ribs
233. Bolted wing root attachment joint strap
234. Front spar
235. Engine bleed air ducting
236. Leading-edge nose ribs
237. Twin landing lamps
238. General Electric CF6-80C2 alternative engine installation



# ON BOARD

with BOAC



British Overseas Airways Corporation (BOAC) was one of the early operators of the revolutionary Boeing 747, and with its introduction came some design innovations, as **Bob O'Brien** discovers.



In 1968, the British Overseas Airways Corporation (BOAC) fleet consisted of Boeing 707s and the British-built Vickers VC10. Although they were very capable aircraft, change was afoot. The dawning age of mass travel called for a different type of airliner and, following years of detailed study and

*BOAC was an early adopter of the Boeing 747, receiving its first example on April 22, 1970.*

*ALL PHOTOS BOB O'BRIEN COLLECTION UNLESS STATED.*

preparation, BOAC decided that its future lay in the 747.

The airline placed an initial order for ten aircraft, with an option for four more. In keeping with many other carriers connected to the 747 project, it had set up residence in the Boeing plant at Everett in Washington state, using its own technical staff to oversee construction of the new equipment.

Such integration was vital to the planning and design process, as the size of the 747 demanded a rethink over matters such as seating and galley arrangements, meal service routines and crew complement – which

had risen to 16 compared with the eight or nine in the VC10s and 707s.

**BOAC**  
IDENTIFICATION TAG  
**SYDNEY**  
**33-04-60**

### Jumbo Innovations

The airline had always prided itself on its standards of customer service, and the introduction of the 747 offered opportunities to find new ways to make flying an extra-special experience for all its passengers.

To oversee the jet's entry into service, a dedicated cabin services team was formed around Allan Blowers, Ken Thorn and Dave Hughes. New galleys were made exclusively for BOAC by a British company, C F Taylor, of Wokingham in Berkshire,

shipped directly to Seattle and incorporated into the fuselage when the aircraft were on the production line.

As the first batch of these 'modular' systems were mostly handmade, they were an expensive and problematic choice, although the concept meant the whole galley could be unplugged from the refrigeration unit and rolled on and off the aircraft in one piece in little more than two or three minutes.

But problems soon arose when the 747s transited to certain overseas stations where catering staff used excessive force in handling the new equipment – and repairing the galleys when down route proved costly, partly because some stations didn't have the expertise to fix the fragile equipment.

The First Class cabin catered for 27 customers in a style befitting BOAC's elite clientele. As well as having the new modular roll-on-roll-off equipment, its galley featured three Herman Smith ovens plus a Litton Industries microwave oven in the cabin's triangular unit, enabling the crew to offer a choice of seven entrées from a freeze box.

A service trolley offered further main courses, including a carved roast joint. When catering for a full load (especially on the hugely popular services to New York), the three members of the First Class team would be joined by the upper-deck operator (usually assigned to the lounge) for the duration of the meal service. In the 747's early days, the crew would carry a carving set whenever on service, inconceivable in today's security-focused climate.

>>

*Wokingham-based C F Taylor was commissioned to design the galleys for the BOAC jumbos. They were shipped directly to Seattle and fitted while the aircraft were on the production line.*





For the rest of the cabin, there were three Herman Smith ovens in galley two and six (plus another Litton microwave) in galley six at the rear of the aircraft.

The 747s were also fitted with BOAC's first in-flight entertainment system, consisting of an 8mm projectors in the roofs of the various cabins, screening one film presentation per sector for the 300-plus passengers – a small charge being made for the rental of a very basic headset. At each transit stop, Inflight Motion Pictures Company representatives would come aboard and change the reels for the next sector.

### Entry into Service

With all systems in place, BOAC received its first 747 on April 22, 1970. But as G-AWNA (c/n 19761) touched down at London/Heathrow to great fanfare, the new fleet was immediately grounded by a dispute between the airline and the pilots' union, the British Airlines Pilots' Association (BALPA), over pay demands for flying the new widebody jet.

During the dispute, however, BOAC gained some much-needed revenue by leasing the Pratt and Whitney JT-9Ds engines of its first three 747s (G-AWNA, G-AWNB and G-AWNC) to other carriers, leaving the trio engineless at its Heathrow engineering base with concrete blocks underneath their engine pylons.

Although the dispute lasted for more than six months, it turned out to be a blessing in disguise owing to the emergence of 'ovalisation' issues with

the engine's fan casings, which caused many carriers to change powerplants down route and after just one flight.

With most of BOAC's industrial relations problems now behind it, the first scheduled service – set for April 18, 1971 – was cancelled just an hour before departure, as a continuing dispute with a different union meant that no flight engineer reported for duty.

The inaugural journey eventually departed a week later using G-AWNF (c/n 19766), which took off at 12:03pm from Heathrow bound for New York.

Captain Duggie Redrup took

**British Airways highlighted the jet's key features in its own promotional brochure.**

**The 747s were also fitted with BOAC's first in-flight entertainment system, consisting of an 8mm projectors in the roofs of the various cabins**



#### In-flight entertainment

British Airways have planned all the entertainment you need to pass the time pleasantly – however long your flight schedule! There are full-length feature films on all the transatlantic daylight flights after the main meal service, with different films on outward and return flights. Passengers can get advance notice of programmes at British Airways check-in counters, but not all Sales/Reservations offices.

Films are not shown on late-night flights, nor on short-sector routes (e.g. New York/Bermuda).

As well as films, we also give you a superb selection of seven audio channels for each passenger! Three channels are in stereo, the rest in mono. There's a complete range of varied programmes, from children's entertainment to popular, light and classical music; interesting talks by famous stars and entertainers; as well as jazz, folk and western music. And of course, the programmes are changed periodically by British Airways.



A small charge of US \$2.50 for the hire of a sterilized headset, is made to each passenger by the cabin staff. The charge is authorised by the IATA, and covers both film and audio entertainment.

command, supported by a crew including Captain Leslie Ward, Senior First Officer Penderol Evans, Senior Engineering Officer Lou Bolton and Flight Purser Ron Hollyer. The service originally operated twice weekly, switching to a daily rotation later that year.

As deliveries continued, the type took on more of BOAC's routes. By May 1972 a thrice-weekly service to Miami, plus a daily rotation to Chicago, were in operation, followed by daily flights between Bermuda and New York and an eight-hour overnight





**Meal service**

When you study the fabulous menus, it's difficult to believe you're so many thousands of feet above the globe! We've even taken the trouble to have special 747 cutlery, crockery and glassware designed for our guests. And we've fitted out six galley areas on each aircraft.

First Class passengers have a choice of several main courses, served oven-fresh for maximum satisfaction. And of course, we use ample hot-plates to ensure that hot dishes don't cool down before you have the opportunity of enjoying them at their best. For special dishes, we have installed a microwave oven, which can individually cook prepared chilled meats in just 35 to 40 seconds!

Nearly 300 Economy Class meals can be heated at the same time in new-design automated ovens, which should keep everybody happy.

Special diets are available on all British Airways services, provided they are requested at the time of booking. Vegetarian, fat-free, salt-free, Kosher and other special meals can be served according to taste or need.

**Baby bars**

Feeding the little people is easy on every British Airways 747—because there are two 'baby-bars' on each aircraft. Both are fitted with special bottle-warming facilities, which heat the contents to just the right temperature.

Stocks of baby food are also on board, to give our youngest passengers a choice of diet.

**Toilets**

Naturally, British Airways have made sure that there are ample toilets, conveniently situated throughout the aircraft. Each one has a make-up table, a large mirror, razor sockets and a supply of iced drinking water. Top-quality women's and men's toilet preparations are freely available.

**Invalids**

If there are any invalids or stretcher-cases on the passenger list, we are fully equipped to give them the best possible flight on any of our 747s. Just tell the agents when bookings are made, and they'll give you all the information you need.

**Seat requests**

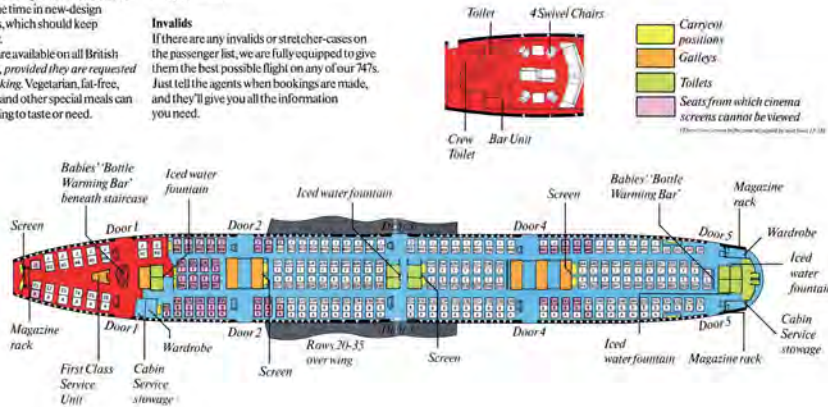
British Airways prefer seat requests to be made in advance at the time flights are booked. Agents can specify the following preferences: (1) cabin; (2) position in cabin—forward, middle or rear; (3) seat position in a row—port or starboard, centre, window or aisle.

Naturally, we do our very best to give passengers the seats they prefer. But we are unable to reserve specific seats by number.

**Promotional material issued by British Airways showed the cabin layout on the 747s.**

BELOW • BOAC introduced its jumbos on routes to Australia in late 1972.

AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION



**BOAC MENU**  
British Airways



**Boeing 747-136  
G-AWNE (c/n 19765)  
was the fifth jumbo  
to join the BOAC fleet.**

AIRTEAMIMAGES.COM/  
ATI COLLECTION

flight to Nairobi.

On November 3, the airline began an Australian service routing via Frankfurt, Beirut, Teheran, Bangkok, Hong Kong and Darwin before landing at either Sydney (twice a week) or Melbourne (once a week).

The service soon switched to a daily link using a much quicker routing via Bahrain – and a technical stopover at either Kuala Lumpur or Singapore – before flying on to Sydney, where a shuttle service to Melbourne was available.

## Upgrades and Retirement

In May 1973, BOAC took delivery of G-AWNE (c/n 20708), its last 747-136. By then the original galley design had become increasingly hard to maintain, and a team was set up to devise a new, more durable system.

The airline opted for a slimline galley system, which increased capacity in the rear cabins from nine to

>>







ten abreast. Meanwhile Galley 1, in First Class, underwent changes too, BOAC also taking the opportunity to fit new premium seats in the cabin. Commissioned once again, C F Taylor carried out the retrofit work in conjunction with the airline's engineering division, completing the modifications in-house.

A second programme under way at the time involved sending the jets back to Boeing's heavy maintenance facility in Wichita, Kansas, to have the upper deck converted from a lounge to a seating area.

On March 31, 1974, the UK Government dissolved the two main British carriers, BOAC and British European Airways (BEA), to form of a new company, British Airways, although BOAC branding could still be seen on parts of the 747 fleet for a few more years. Indeed, it wasn't until G-AWNC was repainted in February 1977 that its colour scheme finally disappeared.

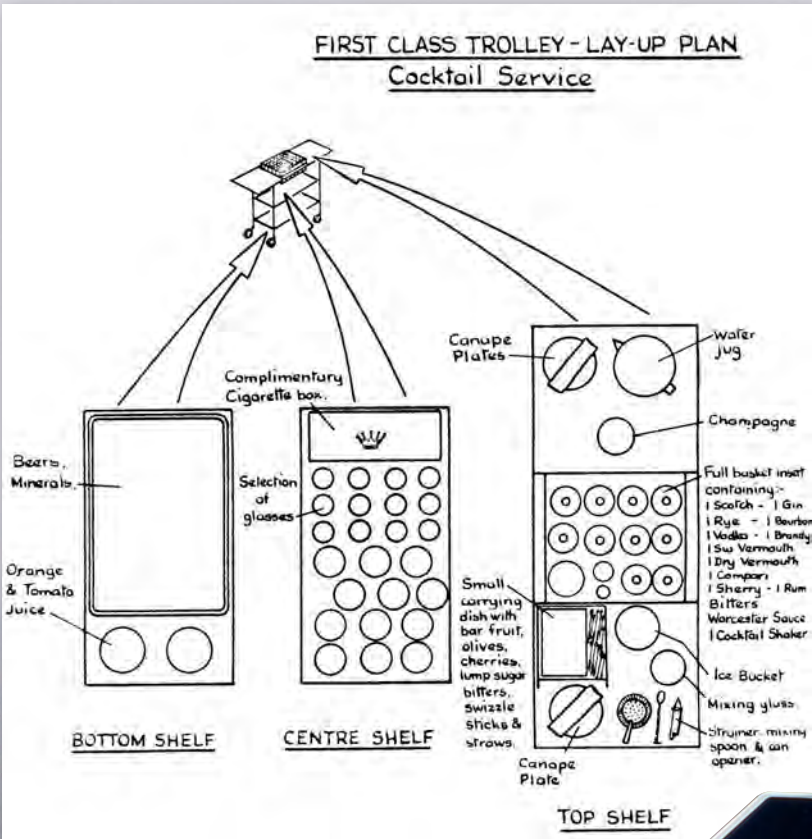
British Airways went on to order five more Boeing 747-136s before the advent of the longer-range -236 variant fitted with Rolls-Royce RB211 engines, the first of which, G-BDXB (c/n 21239), arrived in June 1977. But, once again, entry to service was plagued by industrial action.

On March 31, 1974, the UK Government dissolved the two main British carriers, BOAC and British European Airways (BEA), to form of a new company, British Airways

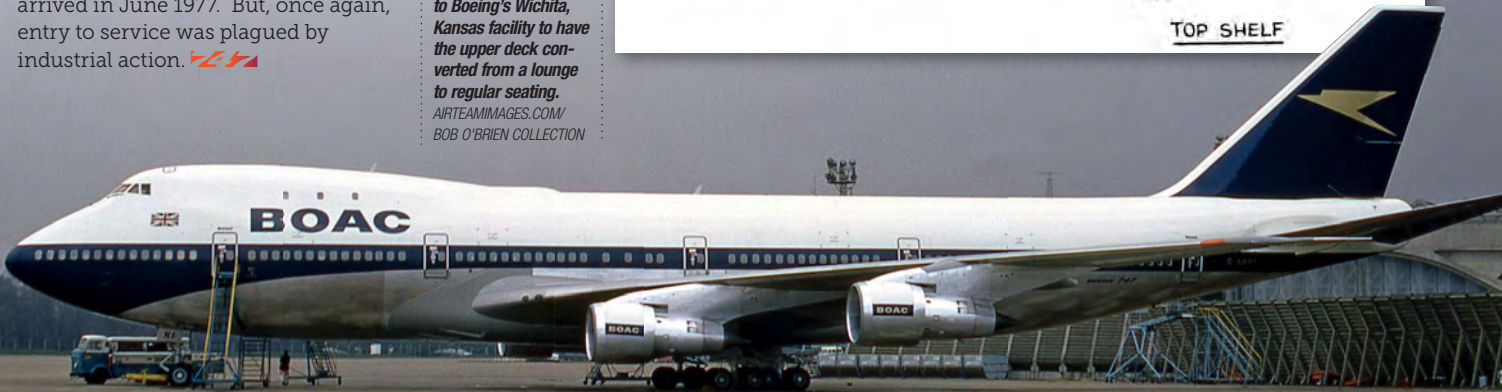
Home comforts:  
BOAC's maiden 747  
G-AWNA taxis at  
London/Heathrow.  
AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION

Jumbo G-AWNC  
basks in the sun-  
shine at Heathrow.  
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BOB O'BRIEN COLLECTION

The BA staff hand-  
book detailed pre-  
ferred trolley lay-  
outs for the First Class  
cocktail service.



BOAC flew its 747s  
to Boeing's Wichita,  
Kansas facility to have  
the upper deck con-  
verted from a lounge  
to regular seating.  
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The Boeing 747-200 sold well throughout the 1970s, and defined the age as one of mass mobility. But the manufacturer was already looking to improve the productivity and efficiency of the jumbo jet, as **Charles Kennedy** discovers.

Airline demand for a longer-range aircraft with an increased payload quickly led Boeing engineers to develop an improved variant of the jumbo by stretching the upper deck – and so the 747-300 was born.

Launched in 1980 with an order from Swissair – which received its first -300 on March 23, 1983 – deliveries to carriers such as Qantas and Cathay Pacific Airways soon followed.

Compared to the -200, its upper deck was stretched aft by 23ft 4in (7.11m) increasing Economy Class seating from 32 to a maximum of 69. The extension called for two new emergency exit doors, and an optional flight crew rest area behind the cockpit could also be fitted. Otherwise the aircraft remained essentially the same as the -200, including its take-off weight and engine options.

Several variants of the -300 were developed by Boeing, including the 747-300M Combi (featuring a cargo area at the rear of the main deck) and the short-range -300SR, built specifically for Japan

# Bigger and Better



Air Lines (JAL) for its high-density domestic services.

Boeing also offered the stretched upper deck as a retrofit for -100/-200 models – two carriers, KLM Royal Dutch Airlines and Union de Transports Aériens (UTA), modifying some of their earlier -200s.

In early 1985, British Airways, Cathay Pacific Airways, Qantas, Singapore Airlines, KLM, Lufthansa and Northwest Airlines assembled a consultative group to compare notes on common requirements for an all-new 747 and lobby Boeing to build it. In response, the manufacturer created the -400, with Northwest becoming its first customer, ordering ten on October 22 that year.

### The -400 Emerges

After three years of design and construction, the first 747-400, N401PW (c/n 23719), rolled out of the hangar at Everett on January 26, 1988; meanwhile, in a coup for Boeing, the first 737-400 rolled out at nearby Renton the same day.

The 'PW' registration suffix

pointed to the new Pratt & Whitney PW4056 engines, the first of three options available to customers.

Under the skin there were extra fuel tanks in the horizontal stabiliser with room for 3,000 gallons (12,000 lit), larger wheels, hi-tech carbon brakes, restyled cabin architecture, a new auxiliary power unit (APU) from Pratt & Whitney Canada and a totally new two-man digital cockpit which reduced the 971 knobs, dials, switches and gauges found in earlier models to a more user-friendly 365.

The -400's upgrades were easily recognisable even to the untrained eye. As well as retaining the stretched upper deck of the -300, wingspan had increased by 17ft (5.2m) and sprouted 6ft (1.8m) winglets, which alone improved fuel burn by 2%. But despite the extra structure, the new wings were 6,000lb (2,700kg) lighter. Overall, the differences were such that the -100, -200, -300 and SP variants became known thereafter as the 'Classics'.

The prototype 747-400's first flight, piloted by James Loesch and Kenneth Higgins on April 29, 1988, lasted 2hrs 26mins. Taking off from Paine Field at Everett, it landed at Boeing Field, just south of downtown Seattle, where the test programme started.

The second 747-400 to fly, N5573S (c/n 23817), powered by General Electric

*German flag carrier Lufthansa was a major customer for the 747-400, operating more than 30 examples. The jet retained the classic jumbo jet lines, but added a modern two-crew glass cockpit, redesigned wings featuring aerodynamic winglets, and a choice of three powerplants.*

AIRTEAMIMAGES.COM/  
HAMFIVE

CF6-80 engines, would become D-ABVB for Lufthansa, while the third, N1788B (c/n 23814), powered by Rolls-Royce RB211-524Gs, later joined Cathay Pacific Airways as VR-HOO. A fourth, N662US (c/n 23720), also powered by PW4056s, operated as a 'hot spare' back-up during the flight test programme.

During testing, one of the jets set the record for the world's heaviest aircraft, getting airborne at a weight of 401,810kg (892,450lbs) at the start of a series of stall tests.

After the FAA certified the Pratt & Whitney-powered version on January 9, 1989, 747-400 N401PW, re-registered N661US and reconfigured to Northwest Airlines' specifications, prepared for its inaugural revenue flight on February 9: a short hop from the airline's hub at Minneapolis to Phoenix. >>





*Launched on the back of an order from Swissair, the 747-300 was much the same as the earlier -200 series, save for an extended upper deck that increased seating capacity to 69.*

*AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION*

*The first 747-400 – powered by Pratt & Whitney P4056 engines – was rolled out at Everett in January 1988 and received FAA certification 12 months later.*

*BOEING*

*The 747-300 shared the same flight deck as the -200, complete with a dedicated station for the Flight Engineer and 971 knobs, dials and switches.*

*AIRTEAMIMAGES.COM/  
ALEX FILIPPOPOULOS*

### Into Service

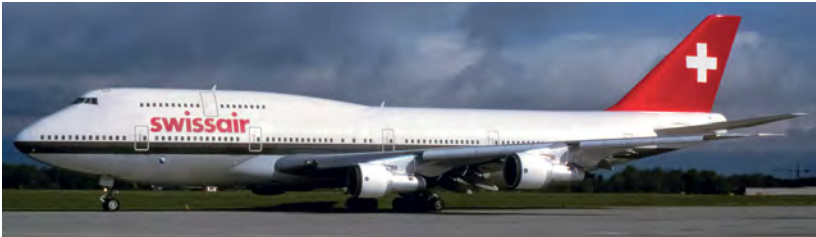
Singapore Airlines, the second carrier to take a 747-400, operated the variant's first international flight, putting its new flagship, branded 'Megatop', into service on the ultra-long-haul route to London on May 31.

Northwest, having kept its -400 on domestic rotations for crew training, launched its own long-haul services with it the next day between New York and Tokyo.

European certification by the Joint Aviation Authorities then hit an unexpected hurdle, with questions over the -400's structural integrity – in particular the floor of the upper deck, which the JAA assessed as unable to survive sudden decompression caused by a 20 sq ft (6.1m<sup>2</sup>) hole without potentially catastrophic damage to control cables and wiring.

While a 90-day temporary certificate enabled KLM and Lufthansa to take delivery of their first jets on May 18 and May 23, to solve the problem, Boeing engineers developed kits to strengthen the floor beams and provided separate control runs, which were retrofitted to the -400s already delivered.

Subsequent aircraft leaving the factory were built to the improved standard. British Airways, the initial airline to operate the Rolls-Royce-powered -400, took delivery its first, G-BNLA (c/n 23908), on June 30.



Qantas, another loyal Rolls-Royce customer, made headlines with the delivery flight of its maiden 747-400, VH-OJA (c/n 24354) *City of Canberra* after it had first been flown from Seattle to London. Then departing on August 17, it flew non-stop from London to Sydney – 11,190 miles (18,001km) – in 20hrs 9mins, setting a distance and endurance record for a jet airliner.

### Golden Years

The 747-400 dominated the long-haul airways of the 1990s and 2000s as the biggest and most prestigious airliner in the sky. Major customers included Singapore Airlines with 42, United Airlines and Lufthansa with 28 each, Qantas with 25 and Air France with 23.

The size, safety and prestige of the 747-400 has led to 11 continuing in







service today as head of state/VIP transports, including one in full Air China livery for the government in Beijing. Other operators include the Japan Self-Defense Forces and South Korean Government, while the Sultan of Brunei flies his own -400. Others are based in the Persian Gulf and one is operated by General Electric as a flying test-bed for new engines.

As they had with the Classic, Boeing developed a sub-type for the demanding Japanese domestic market, where so many passengers fly between major cities that widebody aircraft are the standard. The -400D, successor to the -100SR and -300SR, sold to both Japan Airlines and All Nippon Airways – ANA buying 13 (plus 14 regular -400s) while JAL took nine 'Ds' (and no fewer than 40 regular -400s).

The -400D is easily recognisable for its lack of winglets, which only produce real savings in the cruise. With most domestic sectors in Japan taking under an hour, aircraft weight undermines any saving in fuel burn.

During the Japanese economic boom of the 1990s, some of JAL's 40 mainline -400s had a seating configuration for just 303 passengers, including 91 in Business Class.

United Airlines went even further, with a special layout for some Pacific routes seating 36 in First and a 'bottom-line pleasing' 123 in Business Class, leaving

**Already an existing 747-300 operator, Cathay Pacific was a real driving force behind the -400.**

AIRTEAMIMAGES.COM/  
DARYL CHAPMAN

**JAL acquired the short-range 747-300SR and -400D for use on busy domestic trunk routes.**

AIRTEAMIMAGES.COM/  
EDWIN CHAI

room for only 142 Economy seats.

Some of the most luxurious passenger 747s still fly today: Atlas Air's three -400s are operated on behalf of Angolan oil specialist Sonair on its three-times-a-week 15-hour non-stop service from Luanda to Houston, configured with ten First Class seats, 143 Business and just 36 in Economy.

With subsequent orders, British Airways expanded its 747-436 fleet until

it reached 57, flying twice daily all the way to Sydney and twice daily to Tokyo, Miami, San Francisco as well as adding frequency on rotations to New York.

The BA fleet has passed through three different liveries, starting with the Landor scheme, then taking on more than a dozen identities in the unpopular 'Utopia' or 'World Colours' scheme before settling on the current Chatham Historic Dockyard scheme developed >>







during the Utopia era for Concorde alone.

British Airways asked Boeing for a unique variant, known as the 747 Lite: so four of its -400s (G-CIVE, VG, VH and VI) do not have the 3,300US gal (12,490lit) fuel tank in the vertical stabiliser plumbed in, lowering the jet's maximum take-off weight by 875,015lb (396,900kg) to 839,961lb (381,000kg).

This enabled BA to operate the aircraft more cheaply, paying lower landing and

*After abandoning its earlier plans for the upgraded 747X, Boeing launched the 747-8 Intercontinental in November 2005.*

KEY: BARRY WOODS-TURNER

overflight fees, albeit sacrificing some range. The only visible difference is in the cockpit, where two fuel tank switches are replaced by a blank panel.

### The Jumbo 'Elves'

As early as the 1990s Boeing started looking at a stretched 747, proposing the 747-500X and -600X, plans for which first appeared in public for at the 1996 Farnborough International Airshow. The aircraft featured two different

fuselage lengths, but each used the wing from a 777.

Although generating much curiosity around the world, airlines were not persuaded to make a purchase. By the turn of the century Airbus was gearing up with its own Very Large Aircraft (VLA), the double-deck A380 (in those years known as the "A3XX"), and Boeing stepped back into the fray with two new proposals, each featuring a new and larger wing: the 747X, which had the same fuselage and capacity as the 747-400, and the 747X Stretch, longer by 32ft 9in (10m).

While the 'X' designations didn't make it to the production line, plenty of their design elements went towards creating a somewhat underappreciated step in the jumbo's evolutionary process, the 747-400ER and 747-400ERF. The -400ER was launched on the back of an order by Qantas for six examples, and would be used on the carrier's nonstop services between Melbourne and Los Angeles without incurring any payload penalties. The variant offered the Australian flag carrier an increased maximum take-off weight of 910,000lb (412,775kg) giving a 35,000lb (15,885kg) payload increase or an extra 500 miles (805km) of range.

Qantas was the only airline that really needed the extra performance offered; but cargo airlines, being much







more weight-driven, were eager for the increase in take-off weight to become available, with Boeing delivering 40 747-400ERFs freighters – starting with Air France on October 17, 2002 and ending with the last delivery of any -400 variant, to Kalitta Air on December 22, 2009.

During this period, orders for passenger 747s started to dry up under the onslaught of the big twins – Boeing's own 777 and its European rival, the A380. The last 747-400 passenger airframe, B-18215 (c/n 33737), went to China Airlines on April 26, 2005.

Boeing was now faced with making a leap into the unknown or getting out of the VLA business altogether. Its engineering division had a catch-all 'paper' aeroplane called the 747 Advanced which took advantage of improvements in technology and aerodynamics including raked wingtips and the 'saw-tooth' trailing edge engine nacelle.

On November 14, 2005, the company made a leap of faith and announced the third generation of the mighty 747 – dubbed the 747 Advanced, which later became the 747-8 I (Intercontinental) and -8F freighters.

**The Intercontinental**

Other than 747SPs built in the 1970s, the overall length of the jumbo jet had never been altered. However, the new -8 features a fuselage stretch of 18ft

*Once the flagship of airlines around the globe, the 747-400 is now very much in its twilight years with many long-time operators phasing out the type from service. This includes Cathay Pacific, which withdrew its last examples in 2016.*

AIRTEAMIMAGES.COM/  
COLIN PARKER

*Having marketed its 747-300s as 'Big Top', Singapore Airlines branded its -400s as 'Megatop', a reference to its extended upper deck.*

AIRTEAMIMAGES.COM/  
DEREK PEDLEY

*The 747-8 was one of just two variants of the jumbo jet family after the 747SP to feature a different fuselage size. The latest incarnation incorporates an 18ft 2in (5.6m) stretch, increasing the total length to 250ft 2in (76.25m). BOEING*





**Korean Air is one of just two carriers, with Lufthansa, to acquire the 747-8 Intercontinental. Notably, both operate the jet alongside the Airbus A380, its closest rival in terms of seating capacity.**  
AIRTEAMIMAGES.COM/  
COLIN HUNTER

**Boeing identified the air cargo market as a key target for the 747-8, leading it to develop passenger and freighter variants simultaneously.**  
AIRTEAMIMAGES.COM/  
ELIAS HADJARI

**While the passenger variant of the 747-8 is losing out to more efficient twin jets, the freighter model continues to attract interest from cargo carriers.**  
AIRTEAMIMAGES.COM/  
4X6ZK-MONI SHAFIR

2in (5.6m) over the previous -400, bringing the total length to 250ft 2in (76.25m). Other main changes include a completely redesigned wing, raked wingtips and the selection of General Electric's GEnx as the only engine option.

Production of the first airframes – initially all freighters – began at Everett at the beginning of August, 2008. But even in its new form, the passenger arian was proving to be a tough sell.

By the start of the following year, with only one order secured, Boeing announced publicly that it was "reassessing" the 747-8, especially as production delays pushed the first flight into 2010. Cargolux confirmed it wanted its 13 aircraft while Lufthansa reaffirmed its commitment to the programme by endorsing an order for 19 747-8Is.

The programme gained confidence at the end of 2009 with successful engine runs and an order from Korean Air for ten 747-8Is. On February 8, 2010, N747EX (c/n 35808), the first 747-8F, took to the skies on its maiden flight. After a series of local test flights from Moses Lake, it moved to Palmdale, California, to avoid clashing with the 787- flight test programme at Boeing Field.

The second 747-8 made its inaugural flight on March 15 followed by the third two days later. Interestingly, 2010 was



the only year that Boeing failed to deliver a single 747 in 40 years of production.

The test programme, however, revealed issues that required design changes: most notably the main landing gear doors had to be reshaped as they caused buffeting, and the third test aircraft was dedicated to solving the problem – a weakness identified in structural longerons in the upper fuselage being fixed by using a more robust manufacturing process. But the struc-

tural oscillation and aileron flutter were harder to diagnose. Meanwhile the first passenger variant, N6067E (c/n 38636), took its maiden flight on March 20, 2011 and joined the flight test programme.

The first 747-8F, LX-VCB (c/n 35806), was handed over in a lavish ceremony to launch customer Cargolux at Everett on October 12, enabling it to start piloting training. The FAA awarded type certification two months later, after which the carrier placed the aircraft into







revenue service.

Lufthansa took delivery of the first 747-8I, D-ABYA (c/n 37827), on April 25, 2012, the jet entering service on its Frankfurt to Washington Dulles route.

Cargo airlines have bought the -8F, but not in huge numbers: the 747 ramp-up coincided with a sluggish global economy, so up to the present time, total orders stand at 110 – 41 747-8Is and 69 747-8F freighters.

### ***Long May She Reign***

At the end of 2016, production rates were cut to half an aeroplane a month (six a year) to help keep the line open long enough to build two new Air Force One presidential aircraft to replace the 747-200s used by every US President since George H W Bush plus an expected requirement for new freighters as cargo airlines start to replace their 747-400s early in the next decade.

A major order from US parcel giant UPS for 14 747-8Fs at the end of 2016 will also help keep the production line ticking over. It's the kind of order that Boeing had been holding out for: an

*The 747-8 cockpit incorporates some refinements over the -400 series, but is largely similar enabling pilots to fly both variants under a single type rating.*  
AIRTEAMIMAGES.COM/  
RUDI BOIGELOT

established 747 operator replacing its existing fleet of ageing -400s.

There are 219 747-400 freighters flying today, and for some outsized missions there's nothing else to take its place. With the high payload weights in the freight hauling business, two extra engines really pay their way compared to widebody twins.

So undoubtedly there will be more orders like the UPS windfall and, with the 50th anniversary of the first 747 deliveries only two years away, the Queen of The Skies will celebrate a golden jubilee no other widebody jet can touch. Long may she fly! 🛫🛬





Cathay Pacific used Boeing 747-467 B-HOY (c/n 25351) as a flying billboard to promote its Hong Kong base. The striking 'Asia's World City' livery was later transferred to a 777-300ER when the jumbo was withdrawn from use and scrapped.  
AIRTEAMIMAGES.COM/  
STEVE FLINT



Air Atlanta Icelandic's Boeing 747-428 TF-AAK (c/n 32868) received this stunning paint job for its role as 'Ed Force One', the official transport of rock band Iron Maiden during its 2016 The Book of Souls World Tour.  
AIRTEAMIMAGES.COM/  
DIRK GROTHE



South African Airways celebrated the emergence of post-apartheid South Africa with this eye-catching livery applied to Boeing 747-312 ZS-SAJ (c/n 23027) 'Ndizani'. The colour scheme, inspired by the 'Rainbow Nation' description coined by Archbishop Desmond Tutu, uses the colours of the country's then new national flag.  
AIRTEAMIMAGES.COM/  
SERGE BAILLEUL



Boeing 747-409 B-18210 (c/n 33734) was one of a host of aircraft to wear the co-branded 'Dreamliner' livery. The tailfin carried standard China Airlines markings, but the fuselage featured the blue variation of the manufacturer's house colours.  
AIRTEAMIMAGES.COM/  
TIM DE GROOT







Many special markings, particularly those used by flag carriers, are intended to promote their home nations as tourist destinations. This was the case for Malaysia Airlines' hibiscus-inspired livery, applied to Boeing 747-4HGs 9M-MPB (c/n 25699) and 9M-MPD (c/n 25701).  
AIRTEAMIMAGES.COM/  
STEVE FLINT



Bolivian carrier AeroSur has adorned its Boeing 747-443 CP-2603 (c/n 32339), with a raging yellow bull. The aircraft, named 'Super Torisimo' (a combination of toro – Spanish for bull – and Turismo – tourism), replaced the airline's older 747-300 'Torisimo'.  
AIRTEAMIMAGES.COM/  
JORGE GUARDIA AGUILA



The 'Wunala Dreaming' livery applied by Qantas to Boeing 747-438(ER) VH-OEJ (c/n 32914) was designed by artist John Moriarty and featured kangaroos drawn in an indigenous style, set against a red backdrop said to depict Australia's deserts.  
AIRTEAMIMAGES.COM/  
THOMAS.K



All Nippon Airways repainted several of its 747s into unusual liveries including JA8963 (c/n 25647), which received this whale-themed 'Marine Jumbo' markings to celebrate the Japanese airline carrying its 500 millionth passenger. The colour scheme was so popular that it was later applied to a smaller 767.  
AIRTEAMIMAGES.COM/  
JEAN



Eager to lend support to the local Seattle Seahawks football team ahead of its appearance in the 2014 Super Bowl, Boeing decorated 747-8F test aircraft N770BA (c/n 37564) in this themed livery. The 'Spirit of 12' markings refer to the team's supporters, known as the 12th man.

BOEING



Another All Nippon Airways special livery, this time worn by 747-481(D) JA8957 (c/n 25642), one of an eventual five aircraft repainted to promote the Japanese cartoon Pokémon. This theme was continued inside the cabin, extending to headrests, cabin crew uniforms, IFE system and souvenir bags.

AIRTEAMIMAGES.COM/  
YUKIHIRO KANEKO



These unusual graphics depict Thailand's Royal Barge 'Suphannahong' and were applied by Thai Airways to 747-4D7 HS-TGJ (c/n 24459) to celebrate King Bhumibol the Great's 72nd birthday in 1999.

AIRTEAMIMAGES.COM/  
BILL BLANCHARD



Singapore Airlines used this tropical colour scheme to promote its then new First- and Business-Class cabins. The livery was applied to two 747-412, 9V-SPK (c/n 28023) and 9V-SPL (c/n 26557), but was promptly withdrawn after the former was written off in an accident at Taipei/Taoyuan in October 2000.

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# HEAVY Haulin'

**James Ronayne** profiles Cargolux, an all-Boeing 747 freighter operator with an extensive global network.



*The arrival of the -8Fs has enabled Cargolux to be more flexible with its -400Fs.*  
AIRTEAMIMAGES.COM/  
RUDI BOIGELOT

operations and high slot availability. The CargoCenter boasts bonded and chilled stores, as well as stables for live animals. There is 920,314sq ft (85,500m<sup>2</sup>) of warehouse space with 113 truck docks and ample parking places. The distance from the lorry to aircraft is

just 354ft (108m). The centre has a handling capacity in excess of one million tonnes per year and the airside ramp can accommodate eight widebody aircraft at once.

## Boeing 747-8

Cargolux considered three aircraft when looking at fleet renewal options in 2005 – the Airbus A380 freighter and >>

Cargolux has grown to be Europe's biggest all-cargo airline since it was established in March 1970. It transports consignments on both scheduled and charter services between more than 90 destinations in its worldwide network, using a fleet of 26 Boeing 747 freighters (22 with Cargolux and four with Cargolux Italia). There are 1,800 employees, around 1,400 of which are in Luxembourg where the company is headquartered.

The small, landlocked nation is an ideal base for operations thanks to its central location. All major European cities are accessible by road within 24 hours and the company works with a team of trucking contractors to move freight between the facility and its customers. Luxembourg Airport is also suited to the airline's activities with a 13,120ft (4,000m) runway, all-weather Cat IIIb

*Most of Cargolux's jumbos are named after places in Luxembourg.*  
AIRTEAMIMAGES.COM/  
SIMONE CIARALLI





Cargolux Fleet			
Reg'n	Type		
LX-ECV	Boeing 747-4HQF(ER)	LX-VCB	Boeing 747-8F
LX-FCL	Boeing 747-467F	LX-VCC	Boeing 747-8F
LX-GCL	Boeing 747-467F	LX-VCD	Boeing 747-8F
LX-JCV	Boeing 747-467F	LX-VCE	Boeing 747-8F
LX-OCV*	Boeing 747-4EVF(ER)	LX-VCF	Boeing 747-8F
LX-RCV*	Boeing 747-4R7F	LX-VCG	Boeing 747-8F
LX-SCV	Boeing 747-4R7F	LX-VCH	Boeing 747-8F
LX-TCV*	Boeing 747-4R7F	LX-VCI	Boeing 747-8F
LX-UCV	Boeing 747-4R7F	LX-VCJ	Boeing 747-8F
LX-VCV	Boeing 747-4R7F	LX-VCK	Boeing 747-8F
LX-WCV	Boeing 747-4R7F	LX-VCL	Boeing 747-8F
LX-YCV*	Boeing 747-4R7F	LX-VCN	Boeing 747-8F
LX-VCA	Boeing 747-8F	*Operated by Cargolux Italia	

Boeing's 777F and 747-8F. The former ultimately never came to fruition, Airbus abandoning the proposal before any examples were built, but on paper at least it was unsuited to shorter flights that make up Cargolux's network – the carrier's average flight sector is five-and-a-half hours. Furthermore, it would also have two decks that would need to be

ABOVE RIGHT • Boeing has achieved a payload of 304,238lbs (138 tonnes) with the latest variant – 44,095lbs more than the older model. CARGOLUX

filled, and lacked a nose door.

The 777F has become a popular platform with operators worldwide, but Cargolux opted for the larger 747-8F. The carrier's business model is based on operating one aircraft type, and with 747-400Fs already in the fleet, it had crews available who could be easily trained to operate the new aircraft. The economics were also good for the latest variant of the jumbo, particularly on longer routes and with high loads.

Executive Vice President and Chief Financial Officer, Maxim Strauss,

said: "If the markets are volatile or there is low demand, the 777 is better. If you take low markets and the dual fleet costs, the 777 is always more expensive than the -8 for us. If you are starting a company from scratch, maybe the calculations are different but for us there was no option to get rid of all the -400s in one go. The 777 is a very expensive aircraft; if you look at the market values of a 777 compared with an -8 there is not much difference. You also have to wait longer for the 777."

Together with Japanese carrier Nippon Cargo Airlines, Cargolux was the launch customer for the Boeing 747-8F, placing an order for ten examples on November 15, 2005. A further three were ordered





# History

In January 1979, the airline received its first Boeing 747-200F, LX-DCV, with a second example, LX-ECV, following in October 1980. The jumbo has been associated with the company ever since and in 1990 Cargolux placed an order for three 747-400Fs. The first of those aircraft arrived in November 1993 and was the world's first 747-400F in revenue service, carrying 255,736lb (116 tonnes) on its delivery flight from Seattle, Washington State, to Luxembourg.



in March 2007. The new variant is 18.3ft (5.6m) longer than the -400F and has a payload of 304,238lbs (138 tonnes) – 44,095lbs (20 tonnes) more than the older model. More modern General Electric GENx engines improves the 747-8's fuel efficiency, range and noise reduction.

An additional 747-8F, LX-VCN (c/n 38076), was delivered to the airline last September taking the airline's complement to 14 -8F variants. At the

handover ceremony, Richard Forson, Cargolux President and CEO paid tribute to the aircraft. "Cargolux operates in a highly competitive market. In such an environment, an aircraft that combines economic efficiency with high earning potential gives a clear advantage," he said. "I see the 747-8F as an industry stalwart; this aircraft has already proven its worth for Cargolux in five years of reliable and efficient operation and it will continue to drive growth and reve-

nues for Cargolux in the years to come."

Strauss said the carrier would look to replace its older jets with newer ones. "Going forward, we will re-fleet step-by-step with more modern aircraft and we will probably stabilise with a [total] fleet size of 25," he said. Strauss admitted the company was uncertain what Boeing's plan was for the -8 variant and said in an ideal world its "wish is a -8 with two engines".

The arrival of the -8s has allowed >>

*Outsized cargo can be loaded onto the main deck of the 747 using the nose door. CARGOLUX*



*INSET • The original LX-ECV, Boeing 747-2R7F c/n 22390, was the second jumbo delivered to Cargolux, arriving in Luxembourg in October 1980. AIRTEAMIMAGES.COM/WOLFGANG MENDORF*



*Cargolux 747-8F LX-VCJ blasts off from Miami. AIRTEAMIMAGES.COM/ALEX PEAKE*





Cargolux to use the 747-400Fs more flexibly. The airline owns several of the aircraft and operates the others on favourable lease arrangements. The older jumbos have proved useful for flying into markets where a smaller capacity aircraft is required or to airports where the -8 is not yet certified.

Strauss said: "We have 747-400s which are almost fully repaid or we have them on lease on flexible terms – we only pay when we fly them. If you take a -8, it has ownership costs of, on lease, \$1.5m; you currently get -400s at a third of that. That gives you more flexibility; they don't need to fly 16 hours a day like our -8s are doing. Even if they are not 100% full, only 90%, it's still sufficient."

Strauss said the aircraft that the company owns will be retained to provide flexible capacity and once they reach

*This busy scene perfectly highlights the aircraft's suitability for freight operations with cargo being loaded on the main deck via the nose door and into the holds below simultaneously.*  
AIRTEAMIMAGES.COM/  
BRAM BOTTERMAN

*Ground staff at Luxembourg Airport start preparing LX-VCV for its next journey.*  
KEY-JAMES RONAYNE

around 100,000 cycles, the engines will be removed and kept, and the airframe scrapped.

## Freight

The airline carries a variety of different cargoes and has eight different products in its portfolio, each tailored to needs of individual sectors. The different services, all prefixed with the carrier's 'CV' IATA code are: alive (animals), classic (general cargo), fresh (perishable goods), hazmat (hazardous material), jumbo (outsized goods), pharma (pharmaceutical and healthcare), power (cars/aircraft/engines) and precious (valuable goods ie art).

Cargolux became the world's first GDP (Good Distribution Practice) certified airline for the transportation of pharmaceutical products and offers dedicated

and qualified carrier and ground handling staff trained in their transportation. The airline's fleet of 747s have four independently controlled temperature zones enabling the carriage of different types of goods on the same flight with constant temperatures in each zone.

Thanks to the aircraft's nose door, Cargolux has been able to carry a variety of large items, ranging from helicopters to flight simulators, heavy generators and oil exploration equipment. The airline moves around 3,000 horses a year and can carry 84 on its 747-400Fs and up to 90 on the 747-8F.

The carrier's strongest markets are out of Europe and out of Asia which account for around 35-40% each. The airline has two bases in Asia, one in Hong Kong and the other in Zhengzhou.

## MRO Operations

Luxembourg Airport is dominated by Cargolux's large red hangar which opened in May 2009. At 656ft (200m) wide, 295ft (90m) deep and 138ft (42m) high, it can accommodate two Boeing 747-8s or a pair of Airbus A380s. Here it carries out work up to C checks. Aircraft enter the hangar during the early part of the week when demand is lower and are turned around ready to fly again on the Thursday or Friday when the airline is at its busiest. Strauss said consultants often question why it does not outsource all its maintenance but, for the company, retaining control of the process is crucial. He said: "Our own maintenance is very important for us; the reason being we want a very high daily utilisation.





Historically, we've always been above 15-16 block hours per day and that can only be achieved if all the departments work together. If you outsource it the service is not as good. It is a core pillar; yes, we do cost counting and we look to see what the real cost is but the maintenance is there to cover our whole business model, otherwise it doesn't really work."

Workshops behind the hangar carry out repairs on parts, and Cargolux and Atlas Air have entered into a joint venture (JV) holding a common stock of spare parts for the 747-8. Russian freight airline Air Bridge Cargo is a customer for this service. Instead of all three airlines carrying two spare parts apiece, the JV carries four. Two are positioned in Luxembourg and two in Hong Kong for added flexibility. Repairs for the JV are carried out at Cargolux's hangar.

Third party MRO work is also carried out by the company when its schedule permits, and clients include Corsair, Atlas Air, Air Bridge Cargo and Silk Way. While specialising in 747 line and hangar maintenance, the company also holds approvals for other aircraft, including the 737, 757, 767 and 777. With the fixed costs, personnel and installation in place, Strauss said it made sense to fill the holes in the maintenance schedule with work for other airlines. He said: "The quality we have here is reliable, we never have problems. We have very experienced knowledgeable people."

### The Italian Job

Cargolux Italia was founded in December 2008 with Italian investors. The airline is based at Milan Malpensa Airport and has a fleet of four Boeing 747-400Fs, leased from the parent airline.

"In 2009 we saw the opportunity with

*Cargolux Italia was launched in 2008 and now operates a fleet of four 747-400Fs. AIRTEAMIMAGES.COM/HAMFIVE*




*Executive Vice President and Chief Financial Officer, Maxim Strauss said in an ideal world, Cargolux's "wish is a -8 with two engines". AIRTEAMIMAGES.COM/JAN SEVERIJNS*

*To celebrate its 45th anniversary, Cargolux applied this eye-catching design by Belgian cartoonist Philippe Cruyt to LX-VCN. AIRTEAMIMAGES.COM/DIRK GROTHE*

Alitalia going out of the market," said Strauss. "We saw it as an opportunity to get closer to our customers because we had a lot of trucking from Italy to Luxembourg and we thought it would be better to have our own office there and our own aircraft based there. We also have different traffic rights there; we don't only rely on Luxembourgish traffic rights."

The Italian operation's network and some overhead functions are co-ordinated with Luxembourg but it has its own staff, including flight crews. "They fly specialist routes to Japan but they

also fly on routes to Africa and the US," added Strauss. "It is very flexible – we can exchange the aircraft, so they can wet lease the aircraft to Cargolux when needed. This gives us the flexibility of optimising the schedule, especially in August when the Italians close the offices more or less for a month."

Cargolux has come a long way since it was launched 45 years ago. With a modern fleet and new opportunities arising in the Middle East and China, the airline looks set to further strengthen its position as one of the world's leading cargo operators. 





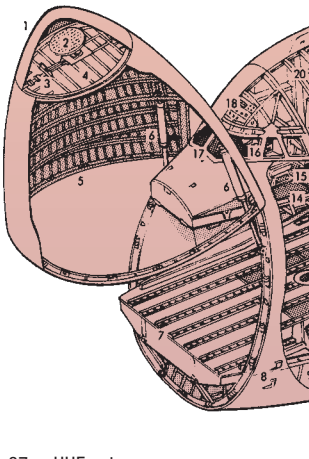
# BOEING 747-400F CUTAWAY

1. Radome
2. Weather radar scanner
3. ILS glideslope antennae
4. Front pressure bulkhead
5. Hinged visor nose cargo door structure
6. Visor section hydraulic jacks
7. Nose aperture loading ramp
8. Pitot heads
9. Nose undercarriage wheel bay
10. Twin nosewheels, forward retracting
11. Nosewheel leg pivot mounting
12. Hydraulic retraction jack
13. 'Powered floor' cargo handling roller trackers and drive wheels
14. Flight deck floor level
15. Two-pilot flight crew. Captain and First Officer's seats
16. Instrument panel shroud, six 8 in x 8 in (20.3cm x 20.3cm) CRT EFIS displays
17. Electrically heated windscreen panels
18. Overhead switch panel
19. Observer's seat
20. Cockpit roof escape hatch
21. Starboard crew service door with escape slide
22. Toilet compartment
23. Crew wardrobe
24. Galley
25. Folding ladder access from main cargo cabin
26. Entry doorway
27. Door-mounted escape chute
28. Avionics equipment racks
29. Fuselage lower lobe frame and stringer structure
30. Forward underfloor cargo hold
31. A 20ft (6.1m) container
32. Upper crew deck floor structure
33. Crew rest seats (six)
34. Single bunk, port and starboard
35. Anti-collision beacon
36. Crew deck aft bulkhead with individual lockers

43. Engine bleed-air duct to heat exchangers
44. Ventral air-conditioning packs, port and starboard
45. Wing centre-box integral fuel tank, total system capacity including optional tailplane tank 57,288 US gal (216,858 lit)
46. Floor beam support structure
47. Conditioned air riser ducts

63. Fuel jettison valve
64. Starboard outboard, low-speed, aileron
65. Aileron internal mass balances
66. Hydraulic actuator
67. Outboard triple-slotted flap

48. Centre fuselage frame and stringer structure
49. Starboard wing inboard main fuel tank
50. Fuel system vent and feed pipes
51. Outboard main fuel tank
52. Starboard pressure refuelling/defuelling connections
53. Leading edge bleed-air ducting
54. Starboard engine nacelles
55. Leading-edge Krüger flaps
56. Krüger flap drive shafts and linkages
57. Dry bay



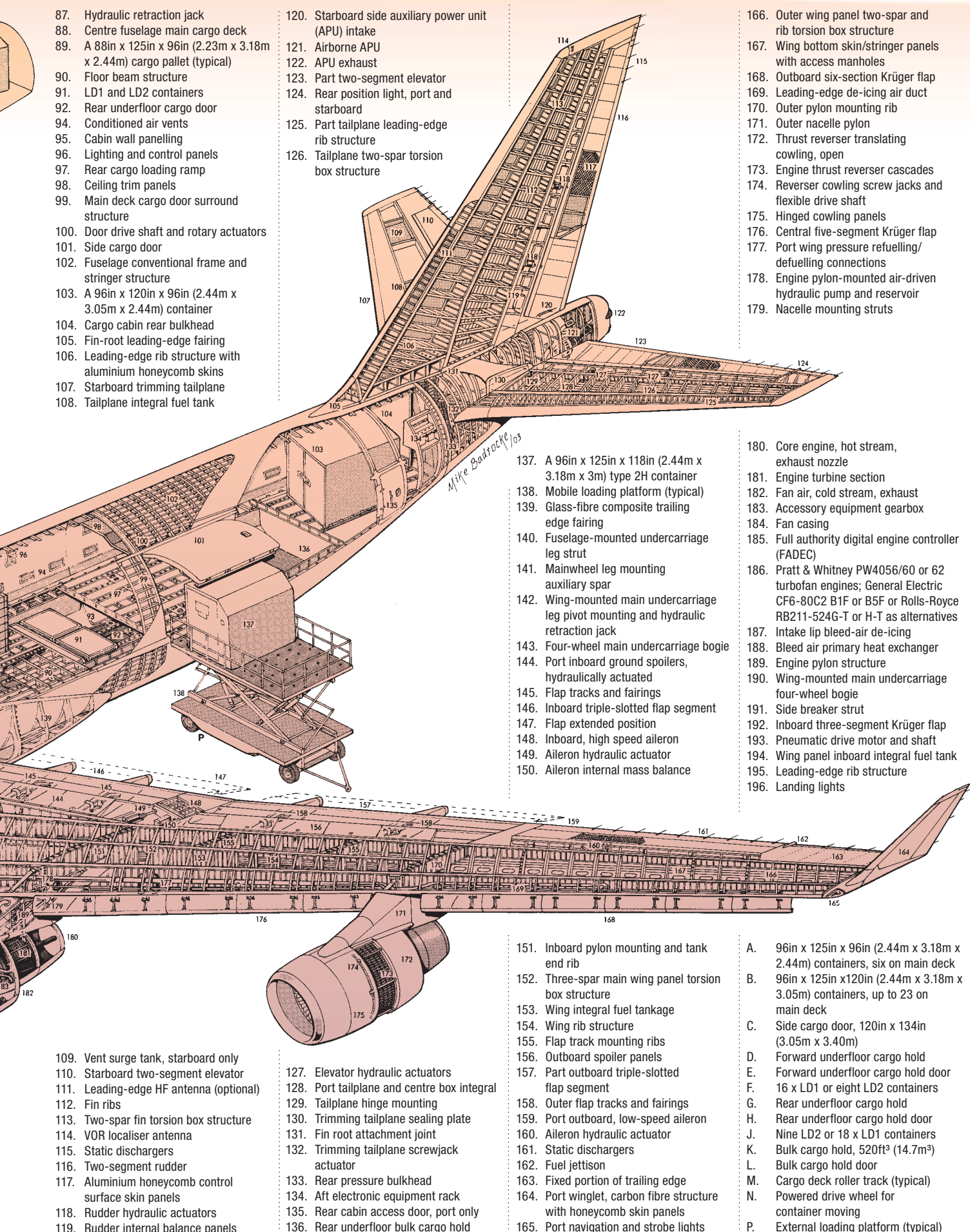
37. UHF antenna
38. A 40ft (12.2m) container
39. Cargo deck roller tracks and tie-down fittings
40. Cabin air outflow valves
41. Wing root leading-edge fairing, glass-fibre composite
42. Conditioning system intake ducts from ventral ram-air intakes

58. Outer wing panel extended-range fuel tank
59. Vent surge tank
60. Starboard navigation and strobe lights
61. Starboard winglet
62. Ventral NACA-type fuel venting air intake

68. Flap guide rails and articulating linkage
69. Flap actuating screw jacks, shaft driven
70. Outboard four-segment spoiler panels
71. Spoiler hydraulic actuators
72. Inboard, high-speed aileron
73. Hydraulic actuator
74. Inboard triple-slotted flap segment
75. Two-segment ground spoilers
76. ADF antennae
77. Cabin wall insulation blankets

78. Conditioned air distribution ducting
79. Pressure floor above wheel bays
80. Wing spar and undercarriage bay fuselage main frames
81. Wing root skin attachment joint
82. Spar/fuselage frame attachment fitting
83. Wing-mounted main undercarriage wheel bay
84. Central flap drive hydraulic motors (x2)
85. Fuselage-mounted main undercarriage wheel bay
86. Mainwheel leg pivot mounting structure





87. Hydraulic retraction jack
88. Centre fuselage main cargo deck
89. A 88in x 125in x 96in (2.23m x 3.18m x 2.44m) cargo pallet (typical)
90. Floor beam structure
91. LD1 and LD2 containers
92. Rear underfloor cargo door
94. Conditioned air vents
95. Cabin wall panelling
96. Lighting and control panels
97. Rear cargo loading ramp
98. Ceiling trim panels
99. Main deck cargo door surround structure
100. Door drive shaft and rotary actuators
101. Side cargo door
102. Fuselage conventional frame and stringer structure
103. A 96in x 120in x 96in (2.44m x 3.05m x 2.44m) container
104. Cargo cabin rear bulkhead
105. Fin-root leading-edge fairing
106. Leading-edge rib structure with aluminium honeycomb skins
107. Starboard trimming tailplane
108. Tailplane integral fuel tank

120. Starboard side auxiliary power unit (APU) intake
121. Airborne APU
122. APU exhaust
123. Part two-segment elevator
124. Rear position light, port and starboard
125. Part tailplane leading-edge rib structure
126. Tailplane two-spar torsion box structure

166. Outer wing panel two-spar and rib torsion box structure
167. Wing bottom skin/stringer panels with access manholes
168. Outboard six-section Krüger flap
169. Leading-edge de-icing air duct
170. Outer pylon mounting rib
171. Outer nacelle pylon
172. Thrust reverser translating cowl, open
173. Engine thrust reverser cascades
174. Reverser cowl screw jacks and flexible drive shaft
175. Hinged cowl panels
176. Central five-segment Krüger flap
177. Port wing pressure refuelling/defuelling connections
178. Engine pylon-mounted air-driven hydraulic pump and reservoir
179. Nacelle mounting struts

137. A 96in x 125in x 118in (2.44m x 3.18m x 3m) type 2H container
138. Mobile loading platform (typical)
139. Glass-fibre composite trailing edge fairing
140. Fuselage-mounted undercarriage leg strut
141. Mainwheel leg mounting auxiliary spar
142. Wing-mounted main undercarriage leg pivot mounting and hydraulic retraction jack
143. Four-wheel main undercarriage bogie
144. Port inboard ground spoilers, hydraulically actuated
145. Flap tracks and fairings
146. Inboard triple-slotted flap segment
147. Flap extended position
148. Inboard, high speed aileron
149. Aileron hydraulic actuator
150. Aileron internal mass balance

180. Core engine, hot stream, exhaust nozzle
181. Engine turbine section
182. Fan air, cold stream, exhaust
183. Accessory equipment gearbox
184. Fan casing
185. Full authority digital engine controller (FADEC)
186. Pratt & Whitney PW4056/60 or 62 turbofan engines; General Electric CF6-80C2 B1F or B5F or Rolls-Royce RB211-524G-T or H-T as alternatives
187. Intake lip bleed-air de-icing
188. Bleed air primary heat exchanger
189. Engine pylon structure
190. Wing-mounted main undercarriage four-wheel bogie
191. Side breaker strut
192. Inboard three-segment Krüger flap
193. Pneumatic drive motor and shaft
194. Wing panel inboard integral fuel tank
195. Leading-edge rib structure
196. Landing lights

109. Vent surge tank, starboard only
110. Starboard two-segment elevator
111. Leading-edge HF antenna (optional)
112. Fin ribs
113. Two-spar fin torsion box structure
114. VOR localiser antenna
115. Static dischargers
116. Two-segment rudder
117. Aluminium honeycomb control surface skin panels
118. Rudder hydraulic actuators
119. Rudder internal balance panels

127. Elevator hydraulic actuators
128. Port tailplane and centre box integral
129. Tailplane hinge mounting
130. Trimming tailplane sealing plate
131. Fin root attachment joint
132. Trimming tailplane screwjack actuator
133. Rear pressure bulkhead
134. Aft electronic equipment rack
135. Rear cabin access door, port only
136. Rear underfloor bulk cargo hold

151. Inboard pylon mounting and tank end rib
152. Three-spar main wing panel torsion box structure
153. Wing integral fuel tankage
154. Wing rib structure
155. Flap track mounting ribs
156. Outboard spoiler panels
157. Part outboard triple-slotted flap segment
158. Outer flap tracks and fairings
159. Port outboard, low-speed aileron
160. Aileron hydraulic actuator
161. Static dischargers
162. Fuel jettison
163. Fixed portion of trailing edge
164. Port winglet, carbon fibre structure with honeycomb skin panels
165. Port navigation and strobe lights

- A. 96in x 125in x 96in (2.44m x 3.18m x 2.44m) containers, six on main deck
- B. 96in x 125in x 120in (2.44m x 3.18m x 3.05m) containers, up to 23 on main deck
- C. Side cargo door, 120in x 134in (3.05m x 3.40m)
- D. Forward underfloor cargo hold
- E. Forward underfloor cargo hold door
- F. 16 x LD1 or eight LD2 containers
- G. Rear underfloor cargo hold
- H. Rear underfloor cargo hold door
- J. Nine LD2 or 18 x LD1 containers
- K. Bulk cargo hold, 520ft<sup>3</sup> (14.7m<sup>3</sup>)
- L. Bulk cargo hold door
- M. Cargo deck roller track (typical)
- N. Powered drive wheel for container moving
- P. External loading platform (typical)



# Testing Times

The maiden flight of any new airliner is a major achievement for a manufacturer, but it's just the start. *Airliner World* talks to **Mark Feuerstein**, Boeing's Chief Pilot, 747 Programs, about his role in the development of the latest -8 variant.

**AW:** As Chief Pilot, Boeing 747 Programs, how do you describe your role?

**MF:** I like to think I'm part of a world-wide team that looks after the safety of the travelling public. Even before an aeroplane makes its maiden flight, a test pilot is an integral part of the engineering team, working to define what the new aircraft is supposed to be capable of.

*The Boeing 747-8F made its first flight on February 8, 2010.*  
ALL PHOTOS BOEING  
UNLESS STATED

During flight testing, we're working with different team members to ensure we've built the aeroplane we intended and that it fulfils the promises Boeing has made to its customers.

After the jet has been certified and deliveries begin, we then have more time to directly engage with our customers, but we also continue to be involved in efforts to improve the aeroplane, sometimes years after the first delivery.

**AW:** During your extensive flying career, what makes the Boeing 747 unique?

**MF:** A lot of things come to mind – its commanding presence in both the aviation industry and in the sky; its speed and economy, which even today makes intercontinental travel possible for so many people.

Many aircraft can claim to have improved aviation, but the 747 has

“Many aircraft can claim to have improved aviation, but the 747 has done more of that than any of us can remember.”







done more of that than any of us can remember. But no other jet to my mind can claim to have been the flagship of so many of the world's airlines.

**AW:** Describe your first encounter with the 747.

**MF:** I didn't fly on an airliner until I was about 14, but my first encounter with the 747 was a trip from Sydney to Los Angeles in about 1991.

I can't claim to have realised then

*Mark Feuerstein, Boeing's Chief Pilot, 747 Programs, believes the GENx 2B engine used to power the 747-8 is a spectacular machine in its own right.*

what a privilege it was to get on board a machine that would fly me effortlessly across the Pacific. I did notice that, for such a large aircraft, it flew very smoothly even during turbulence; and as an engineer/test pilot I knew that a flexible structure was a good thing.

**AW:** When did you first get the opportunity to fly the 747?

**MF:** It would have been around 2001. I joined the 747 programme as assistant chief pilot and, except for a little time

on the 787 and some other projects, I've spent most my time since then flying the Queen of the Skies.

**AW:** From a pilot's perspective, what are the challenges of flying the 747?

**MF:** Taking a long view, I think perhaps the most challenging aspect of the 747 is to maintain its truly outstanding reputation for safety and reliability. Everyone on the programme has a lot of ownership and the bar has been set very high, and >>

## Mark G Feuerstein

Chief Pilot,  
747 Programs Boeing  
Test & Evaluation



Captain Mark Feuerstein is chief pilot for the 747 Programs, responsible for flight test activities related to all Boeing 747 models and working with engineers on the design requirements for all current models and derivatives.

He took up his current position in October 2007, principally focusing on test flying, certification and entry into service of the 747-8 Freighter and Intercontinental. Feuerstein joined Boeing in 1997 and has served as chief pilot New Airplane Product Development, assistant chief pilot for the 747, assistant chief pilot for the 7E7 and deputy pilot for Military and Special Products.

He has a BSc in Aeronautical Engineering from Purdue University, graduated from the US Naval Test Pilot School as an engineering test pilot in 1987, has more than 9,000 flying hours in 100-plus aircraft types and holds an FAA type rating for the 707, 737, 747, 747-400, 747-8, 757, 767, 777, 787, Airbus A320 and A330.







*A job well done: Feuerstein and senior Boeing executives celebrate the first flight of the freighter variant*

*The 747-8I is put through the 'gauntlet test' prior to its first flight.*

*Feuerstein says the aim of any flight test campaign is to find the 'teething problems' so the customer doesn't have to.*

frankly requires daily attention. But speaking more directly as a 747 pilot – and most pilots who've flown the 747 would agree with me – it's a very friendly jet to fly. I wish I could take acclaim for that, but the truth is a lot of people from all over the world should get the credit – from the factory workers and partner companies, regulatory authorities and the airline pilots, cabin staff and mechanics who all work on the aeroplane: to my mind these are the people who have made the 747 the success it is.

**AW:** Can you describe your role in the lead-up to the maiden flight of the 747-8?

**MF:** The years leading up to the first

flight of a new aeroplane are always very busy and the 747-8 was no different: from seemingly endless internal meetings and correspondence to critical meetings with other project partners – including engine manufacturers, systems vendors and alike – to regulators and prospective customers, plus many months of daily simulator evaluations involving the design team, there was always a lot to do.

Through it all, in that pre-flight period, the one thing constantly in my mind was delivering an aeroplane that enables pilots and airlines to do their job of transporting the travelling public safely, efficiently and economically; and, although some opinions may differ, comfortably as well.

**AW:** Can you describe your emotions as you waited to take off on the maiden flight of the -8?

**MF:** I had the privilege of being the Captain on the first flight of the Freighter variant and the Intercontinental about a year later.

I guess I sat in the

cockpit with a confident anticipation. Confident because of the team we had and the work we had already achieved; and with anticipation because it's an enormous privilege and a personal career high for any test pilot to be associated with any new aeroplane.

It can be the result of a life's work for thousands of people, many of whom you will never meet. To be given the keys and trusted to bring the aircraft back in the same condition as you found it is what makes that privilege so enormous.

My co-test pilot, Tom Imrich (he has retired now), was invaluable and indeed he ensured in many ways that we executed our first flight plan. It was great having his experience on board beside me.

The weather is never helpful, and I'm not sure why, but Boeing has flown many of its new aircraft in the winter months, and every year the weather is never very good!

One of the things I remember the most was sitting on the aeroplane, waiting for some fog to lift and all the while knowing that a lot of people were anxious for Tom and me to get going.

Of course, I will tell you I was a little nervous about the landing, just knowing a lot of people were watching live as well as on the internet globally. Many of those people probably already knew from previous versions of the 747 how easy it was to fly, and I wasn't going to have too many excuses if I didn't make a reasonable landing! The pressure was on me, at least in my mind.

**AW:** Every aircraft has its teething problems: what was found during the -8's development?

To be given the keys and trusted to bring the aircraft back in the same condition as you found it is what makes that privilege so enormous.







*Feuerstein was the Captain on the first flight of both variants of the 747-8.*

*Now the 747-8 is in service, Feuerstein says his role involves engaging with the customers to ensure the aircraft is meeting their expectations.*

*More celebrations following the maiden flight of the Intercontinental.*

**MF:** The whole point of flight testing is to find those teething problems so that the customer doesn't have to. I know that sounds a little trite, but the more we find before, and during, flight testing, the happier we are.

When we find areas that need improvement we go back to our

pre-flight method of involving a team of engineering experts to sort through what we know, and figure out what we need to know, so that we can ultimately deliver what we promised. At the end of the day it's all driven by safety, quality and reliability.

Often some of the biggest challenges

of any flight test programme are capturing the right environmental conditions. Inevitably, in my mind – and this has gone on for many years – the requirement for hot weather testing always seems to be scheduled for January in the Northern Hemisphere! So off to Alice Springs in Australia we go.

We fly to Iceland in the wintertime to catch the strong crosswinds of an Atlantic storm, or to Russia for cold weather testing.

We had some interesting challenges during the -8 programme: again we stepped back and said 'alright, how did we design the aeroplane?' – essentially going back to the original template. We sat down and worked through each challenge using the same disciplined and technical processes as before the first flight.

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**AW:** The 747-8 is powered by brand new engines, the GENx turbofans. How do these compare with previous powerplants used on the 747?

**MF:** The GENx 2B engine is a spectacular machine in its own right. They are just unbelievable. It creates about 67,000lb of thrust and that's up from the 747-100 Pratt & Whitney JT9 engines which had two-thirds as much thrust.

Those early engines were very noisy, used quite a lot of fuel and were certainly not as reliable as what we have today. We will never end the process of improvement.

From a pilot's perspective, each successive generation of engine has, looking back, behaved differently. For example, the latest generation of engines from, I think, most if not all the manufacturers take a few seconds longer to start on the ground than their predecessors. Pilots tend to notice things like that when they first fly a new design.

But then they probably don't think too much about that after the first few flights, it just becomes natural. The GENx is a fabulous engine, and with four of them producing more than 250,000lb of thrust, it's a real treat.

**AW:** Can you describe some of the highlights of the 747-8's flight test programme?

**MF:** Every new type has highlights in its development. Sometimes they can be a little obscure – and only the people involved would be excited by them – while others are more interesting.

In the 747-8's case we had a couple of highlights: we did three take-offs with the gross weight of the aircraft

*Air China, Lufthansa and Korean Air all operate the 747-8I.*  
KEY-BARRY WOODS-TURNER

*One of the 747F's biggest selling points is the ability to load bulky cargo via the nose door.*  
KEY-BARRY WOODS-TURNER

*UPS became the latest carrier to sign up for the 747-8F, when it placed a firm order for 14 examples, with options for a further 14, last October.*  
KEY-BARRY WOODS-TURNER

*Cargolux has 14 747-8Fs which it uses to ferry freight around the world.*





over one million pounds (455,000kg) – and that was pretty interesting. We had done a lot of take-offs at about 980,000lb (445,000kg), and adding 20,000lb (9,100kg) didn't bother the aeroplane at all. There wasn't much change in its handling or performance, but for us it was a nice big round number and it sounded good.

Maybe more interestingly, we occasionally landed the jet in the region of 955,000lb (430,000kg). That was a little more challenging than the take-off because the aeroplane is around 25% (one or two per cent either way) above its maximum landing weight, but it isn't particularly difficult to do. But I will admit there's more of a threat of a meeting with the chief pilot should something go wrong!

During the certification process we intentionally flew a little bit faster – at Mach 0.97! We also carried out hundreds of full stalls to make sure the jet was well behaved and predictable.

All the work was done by about 40 pilots; and we were accompanied by many engineers over the course of the test programme, and we used seven different test aeroplanes.

In all it was quite a production. I was responsible for managing all these people as well as flying the aeroplane. It isn't for me to say whether I did a good job or not, but we achieved our goals. Both the Freighter and the Intercontinental variants were certified and have been in service for five years now, and I still have my job!

**AW:** Was the certification process simplified?

**MF:** The 747-8 did what we called an amended type certification. The type certification frames what work needs to be done.

From a certification standpoint



*Feuerstein addresses the international media during the 2011 Paris Air Show.*

KEY-BARRY WOODS-TURNER

it's fair to say that the engineering challenge for Boeing, our partners and the regulators was still substantial for a derivative design, and in some ways was more challenging than a clean sheet design.

**AW:** Once the jet had been certified and entered service, how did your role change?

**MF:** That's a good question: I go to a lot of meetings! Once certification was completed, our attention turned to producing the aeroplane and delivering it to our customers.

We have, at Everett and Renton, teams that specialise in demonstrating the aeroplane to potential customers. Sometimes I'm involved in those flights, but I also probably spend more of my time standing in front of our customers around the world to ensure we're continuing to meet their expectations and to answer their questions.

**AW:** With the aircraft in service for five years now, are you still working on improvements?


**MF:** We're continuously focusing on improving the aeroplane, so dialogue with customers becomes a very important part of my job. That means I continue to work with the engineering teams, just like we did before the first flight, so that process never really ends.

Yes, I'm still involved in developmental testing, mostly on projects related to the 747 – and with so many variants still flying worldwide there's plenty to do.

I readily admit the pace is a little slower than at the height of the development and test programme, but [with] the variety and the scope of what we do to maintain and continually improve the aeroplane there's plenty to do.

**AW:** With orders slowing down, what do you think the future holds for the 747?

**MF:** I get asked that question a lot. The funny thing about orders slowing down, if you think about it, is that's what they do before and after they speed up. If you go back in history, this is about the fifth time since 1970 that our orders have slowed down.

But what remains constant through that period is the continuous effort to improve the aeroplane and the continuous truth that the future of the 747 is an exciting opportunity to excel. Nothing has changed. 

“During the certification process we intentionally flew a little bit faster – at Mach 0.97!”

*Lufthansa is currently the largest operator of the 747-8 with a fleet of 19 Intercontinentals*





The ungainly Boeing 747 Dreamlifter was developed to carry subsections of the 787 Dreamliner from various production facilities around the world to the final assembly lines at Seattle and North Charleston.

The Large Cargo Freighter conversion, completed in Taiwan by Evergreen Aviation Technologies, included modifying the fuselage and adding a swing tail to enable unrestricted access to the vast cargo hold.

AIRTEAMIMAGES.COM/  
ANDRE NORDHEIM



**Air Force One:** The two VC-25As operated by the Presidential Airlift Group, 89th Air Wing at Joint Base Andrews, Maryland, are arguably the most recognisable 747s ever built. The US Air Force jets are specially configured for the role, serving as a mobile 'White House' when the US President is travelling.

AIRTEAMIMAGES.COM/  
KEVIN BOYDSTON



**Space Shuttle 'Endeavour'** sits atop one of NASA's two Boeing 747-100 Shuttle Carrier Aircraft. The modified jumbos, retired at the end of the shuttle programme in 2012, were used to ferry the orbiters from various landing sites back to the Shuttle Landing Facility at Kennedy Space Center, Florida.

AIRTEAMIMAGES.COM/  
JORGE CHAVEZ



With 747s now widely available on the second-hand market, the type is finding use in increasingly specialist roles. Global SuperTanker Services converted this -400, N744ST (c/n 25308) into an aerial firefighter capable of carrying almost 20,000 US gal (75,700 lit) of water, gel or foam retardant.

AIRTEAMIMAGES.COM/  
IDO WACHTEL







The USAF used a Boeing 747-400F as an Airborne Laser Testbed. The YAL-1, which had a mega-watt-class chemical oxygen iodine laser (COIL) mounted on a turret in the nose, was trialled as a missile defence system but was withdrawn from service in 2012.

BOEING



Former Pan Am 747SP N747NA (c/n 21441), was rescued from desert storage and given a new lease of life as a flying telescope under the SOFIA programme, a jointly funded initiative between NASA and the German Aerospace Centre (DLR).

ANDY MARTIN



The 747 has proven itself to be a versatile platform and is used for a wide range of development work. Pratt & Whitney employ former Air China 747SP-J6 C-FAW (c/n 21934) as a flying test-bed for new engines.

PRATT & WHITNEY



Rolls-Royce's Boeing 747-267B N787RR (c/n 21966) performs a vital role, taking the firm's new powerplants into the air for development and testing. Here, the 'Spirit of Excellence' puts the Trent 1000 through its paces.

ROLLS-ROYCE



Commonly referred to as the 'doomsday' aircraft, the USAF's E-4B Nightwatch serves as the National Airborne Operations Center, following the US President and Secretary of Defense around the world providing command, control and communications functions in the event of war or natural disaster.

AIRTEAMIMAGES.COM/  
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# JUMBO POWER

When developing a new aircraft, the choice of engine can be critical to the success, or otherwise, of the design. And when the type is unlike anything that has flown previously, there is even more risk attached, as was the case with the Boeing 747. Early examples were powered by Pratt & Whitney's (P&W) JT9D-3, the first model of the mass-produced JT9D family, and an engine that remains in limited use (albeit later variants) almost 50 years after production began.

The initial choice of powerplant was dictated largely by circumstance. After the Seattle firm lost out on the USAF CX-Heavy Logistic System contract to Lockheed and its C-5 Galaxy, it salvaged what it could from its failed design and re-used it on what became the 747. However, this did not include

the engines – the USAF had selected General Electric's (GE) TF39 first-generation high-bypass turbofan to power its new heavy lifters, leaving Boeing to find an alternative – enter P&W.

The engine manufacturer was contracted in late 1966 to produce a rival design, but it was under pressure from the outset. GE benefitted from government funding for its TF39, which it ultimately developed into the highly successful CF6 family of engines, whereas P&W had little option but to privately fund the design and development of the JT9D. Furthermore, Boeing had committed to deliver the first 747s to launch customer Pan Am within 28 months.

The resulting engine – the first commercial high-bypass turbofan – was a tremendous technological

The Boeing 747 and its numerous sub-variants have been powered by a wide variety of engines from all of the 'big three' manufacturers over the almost five decades since the type first took to the air. **Chris Kjelgaard** examines the 48-year evolution of the jumbo jet's powerplants.



“The resulting engine – the first commercial high-bypass turbofan – was a tremendous technological achievement”

achievement but the haste with which it was designed and certified meant teething problems were almost inevitable. Throughout their operating lives, the initial JT9D-3, and the JT9D-3A that followed, suffered from well-documented reliability issues in terms of the number of engine removals required, and the low average times-on-wing they achieved.

One common criticism of the original 747-100 was that it was underpowered. This was rectified in part by the JT9D-3A, which gave an additional 2,300lb of thrust per engine and helped to improve take-off and initial climb performance. This was achieved through the introduction of water injection, which reduced the temperature of the air entering the combustor.

### ‘Ovalising’

Two technical issues with the early JT9Ds were significant. First was the tendency in -3s for engine beams to bend and the compressor and turbine casings to ‘ovalise’. This caused high-pressure compressor and turbine blades to rub against the inner lining to such an extent that early 747-100 operators commonly replaced engines after just one long-haul flight.

The ovalising problem had resulted from Boeing’s decision to mount the thrust link (the assembly that transmits thrust generated by the engine to the airframe) to the engine pylon at a single point on the turbine casing. The norm at the time was >>

*Jumbo Sunset: Once the flagship of fleets across the globe, the 747 is now losing out to more efficient twin-jets.*

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ALEX FILIPPOPOULOS





“The second technical issue, experienced by the JT9D-3/3A as well as the later -70A, was frequent compressor stalls.”

to mount a second thrust link on the compressor casing. The eventual fix – a new inverted Y-shaped frame that transferred much of the thrust load onto two points rather than one – was introduced in 1969 and came about after Boeing employed stress analysis software originally developed for the 727.

### Compressor Stalls

The second technical issue, experienced by the JT9D-3/3A as well as the later -70A, was frequent compressor stalls. These were particularly prevalent when a tailwind was blowing into the back of the engine during start-up, but also when the powerplant was spooled up or down too quickly. In turn, the stalls often led to engine flame-outs and generally contributed to a rapid deterioration in performance.

The problem was traced to the

engine's complicated bleed air system and exacerbated by aerodynamic interference between the pylon and fan casing, which produced back-pressure on the fan and caused re-ingestion of fan-exit air into the compressor intake. This was resolved by twisting selected upper-engine fan-exit guide vanes to divert the airflow around the pylon.

However, reducing the number of compressor stalls when thrust was reduced at the top-of-climb was more complicated, and eventually Boeing installed metal bars to 747 thrust-lever quadrants to prevent pilots from closing the levers completely. Crews were also given additional training

to close and open the thrust levers at pre-determined rates, particularly during take-off and at the top of the climb phase. In some instances, airlines insisted on this being undertaken by flight engineers, who were better acquainted with the nuances of the JT9Ds.

### Common Ground

In the almost five decades since the 747 first took to the skies, the aircraft has undergone some fundamental changes, through the more powerful -200 – the first variant to offer a range of powerplants from all 'big three' manufacturers, Rolls-Royce, P&W and General Electric – and the glass cockpit-equipped -400 to the

*Over the course of its almost 50-year career, the 747 has been powered by engines from all of the 'big three' manufacturers – GE Aviation, Pratt & Whitney and Rolls-Royce.*

AIRTEAMIMAGES.COM/  
NUSTYR

*The JT9D-3 series suffered frequently from compressor stalls, especially if they were exposed to a tailwind or were spooled up or down too quickly. Reliability was improved significantly on the later JT9D-7.*

AIRTEAMIMAGES.COM/  
ALEX FILIPPOPOULOS



*The 747-200 featured an increased gross weight and more powerful engines from a choice of manufacturers. This included Pratt & Whitney's JT9D-7, which offered around 48,000lb of thrust over the 43,500lb of its predecessor, the JT9D-3.*

*AIRTEAMIMAGES.COM/  
EUROPIX AND WEIMENG*



40,000-50,000hrs before it requires a performance-restoration shop visit. By comparison, few if any JT9D-3As achieved more than 4,500hrs time-on-wing before requiring removal for repair.

Elsewhere, the GE powerplant employs cutting-edge 3D aerodynamic aerofoil designs in its fan, compressor

and turbine blades. Development of advanced computational flow dynamics analysis, along with decades of design and testing experience, enabled the manufacturer to reduce the number of fan blades in the engine, from 38 in GE's previous-generation CF6-80C2 to just 18. Furthermore, these are now made from layers of woven carbon fibre >>

current model, the 747-8.

The GE Aviation GENx-2B67B engine powering the latest incarnation shares common ground with the first-generation JT9D-3A, namely in their very similar power-to-weight ratios (5.45:1 and 5.32:1 respectively). However, in terms of performance and technology, the difference between the engines is quite dramatic, says Tom Walker, Executive Program Manager for the GENx-2B.

He explained that the materials used in the hot section of the GENx-2B67B, which is largely identical to the GENx-1B powering the 787 (save for a smaller fan diameter and one fewer low-pressure compressor and turbine stages) are far more advanced than those in all the older 747 engines. As a result, the engine is considerably more durable than previous-generation powerplants – it will typically stay on wing for







“...it is likely the GEnx may well be the last powerplant for the 747 family.”

embedded in a resin matrix to form a composite, greatly reducing their weight while making them “extremely durable” claims Walker. “There is very little maintenance required.”

The fan case of the GEnx family is also made of carbon-fibre composites, saving a further 350lb (159kg) in weight.

The engine has enjoyed a relatively trouble-free introduction and, to date, GE says it has encountered only one technical issue with the powerplant that

*The GE Aviation GEnx-2B has a similar power-to-weight ratio to the original JT9D-3, though in terms of performance and technology, it is light years ahead.*

GE AVIATION

required modifications. Notably, the problem – ice crystals forming on the fan blades then breaking off and being ingested into the engine – was not serious enough to require an emergency airworthiness directive (issued by the certifying authority when immediate action is necessary). Rather, the minor hardware and software changes that are needed are mandated in a service bulletin and are being rolled out during routine servicing.

### Compressor and Turbine Advances

The new fan blade design on the GEnx means it has a far higher bypass ratio – thrust-producing cold air that is pushed by the fan around the engine core – than earlier designs. At take-off power, this is around 8:1, compared with 4.4:1 on the CF6.

The material and aerodynamic advances of the powerplant are not restricted to its fan section, but also





extend to the core. This includes the low- and high-pressure compressors and turbine stages, which also have 3D design blades and vanes.

Notably, three rotating stages of the high-pressure compressor feature one-piece bladed disks – dubbed 'blisks'. These replace hundreds of individual compressor blades, vastly reducing the number of components in the engine and making it more aerodynamically efficient.

The Genx family also employs advanced cooling techniques to improve the thermal efficiency of the engines' high-pressure turbine (HPT) modules, helping to insulate the various metal alloys from the intense

**The Genx-2B used on the 747-8 is largely similar to the -1B that powers the 787 Dreamliner.** KEY-BARRY WOODS-TURNER

**ABOVE RIGHT • The Genx has a specific fuel consumption some 13% lower than the CF6-80C2 it replaced.** BOEING

**GE Aviation says the Genx combines cutting-edge design with advanced material technology.** GE AVIATION




turbine inlet temperatures that reach almost 1,482°C (2,700°F). This includes complex patterns of cooling-air pathways on the rotating blades, and thermal barrier coatings. The LPT and HPT casings also have active clearance control – shrinking or expanding as necessary to maintain maximum efficiency throughout all phases of flight.

The numerous advancements built into the Genx, together with its sophisticated FADEC III (full authority digital engine control) system and high bypass ratio, make the powerplant one of the most fuel efficient – and quietest – in service today, the manufacturer claims.

According to Walker, its specific fuel

consumption is 13% lower than that of the CF6-80C2, the immediate-predecessor 747 engine, 20% lower than the CF6-50C2 that powered many 747-200Bs and considerably more again over the original JT9D-3.

There is little doubt the latest incarnation of the 'Queen of the Skies' has evolved significantly from the prototype that was rolled out at Everett in 1969, but arguably some of the biggest advances have come from the engines that power the giant jet. However, with dwindling orders and an industry increasingly leaning towards cheaper and more efficient twins, it is likely the Genx may well be the last powerplant for the 747 family. 







With the 747-100 and -200 established in airline service, Boeing looked for opportunities to develop the basic airframe and increase its sales appeal.

### **Andy Martin**

examines the next derivative offered to airlines - the 747SP, the 'hot-rod' Jumbo.

# 747SP Special Performance

**D**uring the early 1970s Boeing, saddled with an almost overbearing need to recover the cost of developing the original Jumbo Jet, could not justify building a slightly smaller widebody to rival the TriStar and DC-10 being developed by Lockheed and McDonnell Douglas. However, in 1973 Pan American World Airways and Iran Air gave Boeing an opportunity to compete when they issued requirements for an aircraft capable of linking the USA with Asia

and the Middle East non-stop: what started out as the 747SB (short body) became the 747SP – the fastest, longest ranged and highest climbing derivative at the time.

### **Third 747 variant**

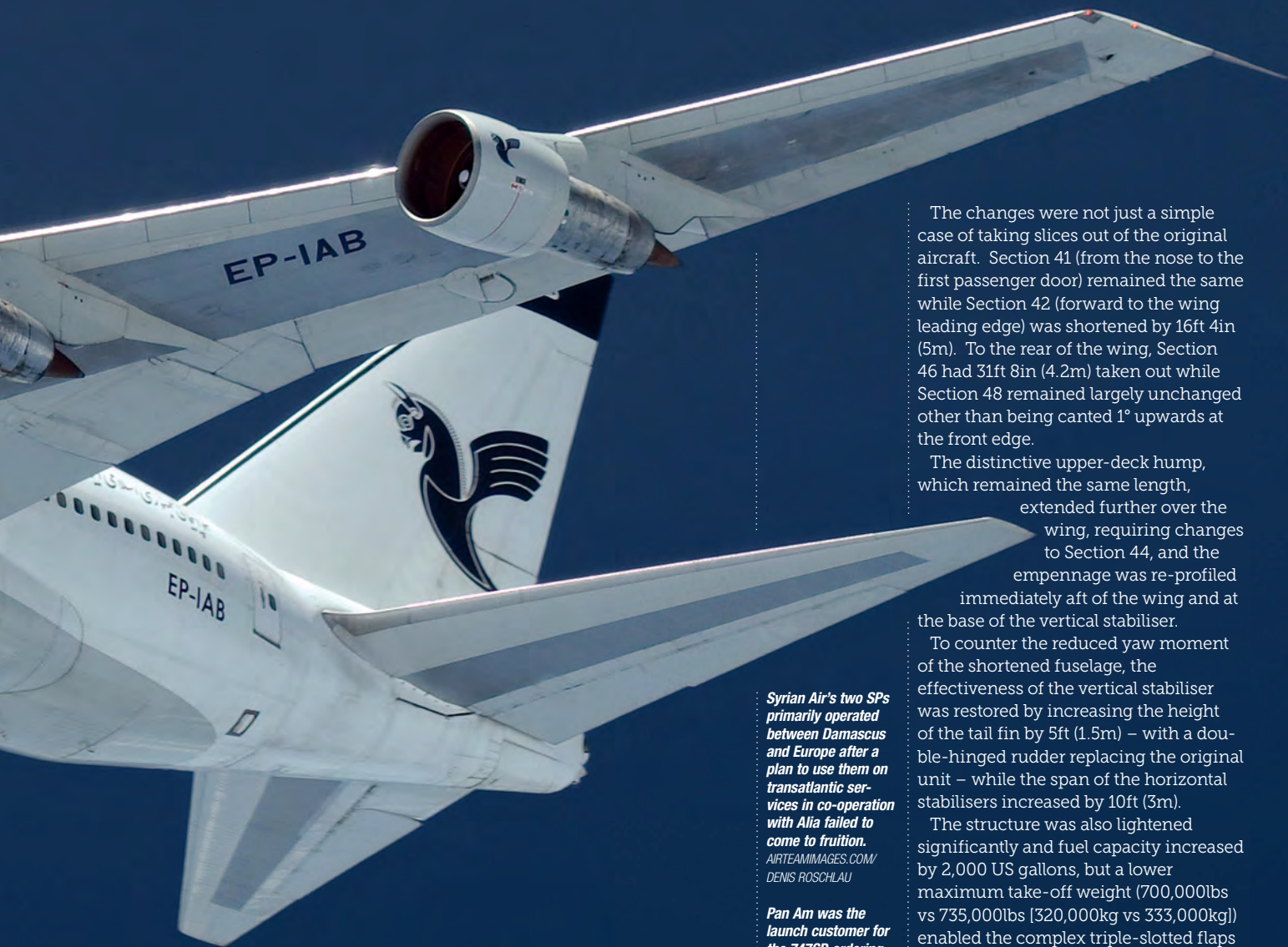
Joe Sutter was quick to seize the opportunity presented by the two airlines and designed a 747 derivative with a shorter fuselage and a lighter airframe – and which could carry more fuel. A higher cruise speed and longer range were advantages Boeing hoped would

*Iran Air became the second customer for the Boeing 747SP when it ordered four to be used on non-stop flights between Tehran and New York.*  
AVIATION IMAGE NETWORK/  
BAILEY

also help the 747SB compete with the rival Lockheed and McDonnell Douglas tri-jets.

The new variant involved much more than 'a cut and shut' of the original airframe. Its fuselage was 48ft 4in (14.73m) shorter than the 747-100, limiting capacity to 276 passengers in a typical three-class layout or 400 in high-density configuration, while nose-to-tail length came down by 47ft 1in (14.36m). Underfloor space for cargo and baggage was cut by almost 40% to 3,900 cu ft (110m<sup>3</sup>).





*Syrian Air's two SPs primarily operated between Damascus and Europe after a plan to use them on transatlantic services in co-operation with Alia failed to come to fruition.*

AIRTEAMIMAGES.COM/  
DENIS ROSCHLAU

*Pan Am was the launch customer for the 747SP, ordering ten examples in 1973.*

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DENIS ROSCHLAU

The changes were not just a simple case of taking slices out of the original aircraft. Section 41 (from the nose to the first passenger door) remained the same while Section 42 (forward to the wing leading edge) was shortened by 16ft 4in (5m). To the rear of the wing, Section 46 had 31ft 8in (4.2m) taken out while Section 48 remained largely unchanged other than being canted 1° upwards at the front edge.

The distinctive upper-deck hump, which remained the same length, extended further over the wing, requiring changes to Section 44, and the empennage was re-profiled immediately aft of the wing and at the base of the vertical stabiliser.

To counter the reduced yaw moment of the shortened fuselage, the effectiveness of the vertical stabiliser was restored by increasing the height of the tail fin by 5ft (1.5m) – with a double-hinged rudder replacing the original unit – while the span of the horizontal stabilisers increased by 10ft (3m).

The structure was also lightened significantly and fuel capacity increased by 2,000 US gallons, but a lower maximum take-off weight (700,000lbs vs 735,000lbs [320,000kg vs 333,000kg]) enabled the complex triple-slotted flaps to be replaced with much simpler single-slotted devices, which also improved airfield performance and reduced take-off roll.

Crucially, the changes enabled the 747SB to cruise slightly faster, climb more quickly and fly 1,400 miles (2,250km) further than the standard Jumbo of the day.

The new variant was noticeably shorter than the original 747 while its tail was obviously taller and slimmer at the top. But beauty is in the eye of the beholder: while some regarded the SP as the runt of the litter, others claimed its proportions were aesthetically pleasing and more balanced. It gained the nickname 'Sutter's Balloon' after the type's chief designer, but before entering service Boeing renamed it 747SP – Special Performance. Meanwhile ICAO designated it B74S while IATA timetables went for the less obvious 74L (long-range).

## Production

Series production of the SP began on the basis of a \$280m order from Pan Am for ten (plus 15 options), and the first rolled out of the Everett factory on May 19, 1975 – it was the 265th Jumbo built. >>







Little more than six weeks after it first appeared outside, the prototype SP made its inaugural flight on US Independence Day.

Boeing hoped to sell more than 200 SPs and to break even after 45 were built, but orders trickled in only slowly while flight trials continued. Iran Air took four, and South African Airways opted for six for direct non-stop services between Cape Town and London round the west coast of Africa, a route that was necessary at the time owing to sanctions imposed by countries opposed to apartheid.

**TOP • South African Airways used the 747SPs to fly non-stop between Cape Town and London.**  
AIRTEAMIMAGES.COM/  
BOB O'BRIEN COLLECTION

**ABOVE • Boeing 747SP-68 HZ-AIF (c/n 22503) was transferred to the Saudi Royal Flight in 2005.**  
AIRTEAMIMAGES.COM/TT

**American Airlines acquired two SPs from TWA in the late 1980s.** AIRTEAMIMAGES.COM/CARL FORD

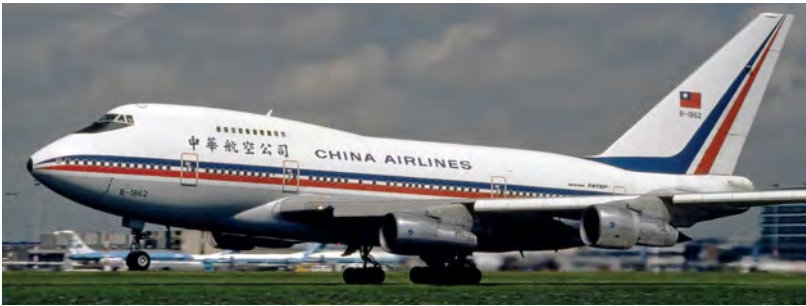
Syrian Arab Airlines also ordered two for flights between Damascus and New York via Amman in co-operation with Alia (Royal Jordanian Airlines), but the service was still-born and the pair spent most of their lives plying routes to Europe.

China Airlines took four for non-stop flights between

Taipei and the US West Coast; Korean Air Lines ordered two to develop links between Seoul and New York; and Civil Aviation Administration of China (CAAC - Air China) acquired three for routes to the US, starting with Beijing to Seattle. In a similar vein two SPs, powered by Rolls-Royce RB211 engines, joined the Qantas fleet, enabling it to fly the lucrative route between Sydney and Los Angeles direct, avoiding a fuel-stop in Hawaii. They also served Wellington where the runway was too short for a normal 747.







**Qantas' two RB211-powered 747SP-38s were used launch non-stop flights between Sydney and Los Angeles.**

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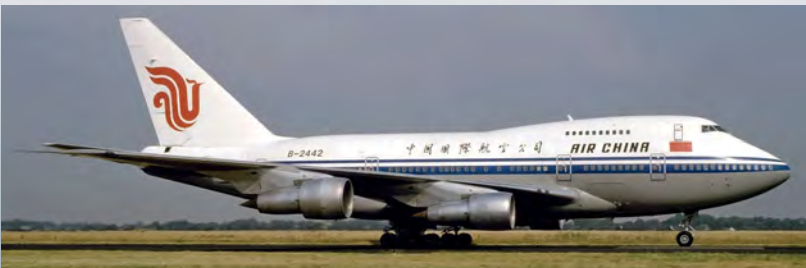
**China Airlines' SPs were frequent visitors to Amsterdam, and to California.**

AIRTEAMIMAGES.COM/  
WOLFGANG MENDORF



**United Airlines acquired ten SPs, along with several transpacific routes, from Pan Am in 1986.**

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BOB O'BRIEN COLLECTION



**Air China (originally CAAC) used 747SPs to open new long-haul links to the USA.**

AIRTEAMIMAGES.COM/  
WOLFGANG MENDORF

**The Yemen Government flew this 747SP-27, 70-YMN (c/n 21786).** AVIATION IMAGE NETWORK/BAILEY

Saudia (later Saudi Arabian) also ordered three RR-powered aircraft, two for its own use and one which served with the Royal Flight. Other operators that acquired SPs from the factory included Trans World Airlines (three) and Braniff International Airways (four). The 44th and last-but-one SP rolled out at the end of August 1982 prior to it being delivered to Iraqi Airways, which flew it on behalf of the government as Saddam Hussein's personal transport – one of only four were built during that year, production having peaked in 1976 when 14 were built. After a break of five years Boeing agreed to produce one more SP, for the government of the United Arab Emirates. It was completed in 1987, but a further two years elapsed before its interior was fitted out.

When production ended 45 SPs had been built on the same assembly line as standard 747s; six were powered by Rolls-Royce RB211-524s and the rest by Pratt & Whitney JT9D engines.

### Record breaker

For a while the 747SP was the undisputed king of long-range air services. But developments in engine technology, new lightweight materials and increases in gross weight later allowed Boeing to improve the 747-200 and develop the 747-400, which matched and then exceeded the range of the SP while carrying a more passengers and cargo.

During its airline career, the SP set three records for circumnavigating the globe. Between May 1 and 3, 1976, Pan Am 747SP-21 N531PA *Clipper Liberty Bell* flew around the world from New York John F Kennedy, via Delhi and Tokyo, covering 23,137 miles (37,235km) in 46 hours 26 minutes. Then from October 28 to 30 the following year, the same aircraft circumnavigated the world from San Francisco – via the North and South Poles and with stops in London, >>





Cape Town and Auckland – in 54 hours 7 minutes, the fastest via a polar route crossing the equator twice.

Finally between January 29 and 31, 1988, United Airlines N147UA *Friendship One* went around the globe in 35 hours 54 minutes, starting and ending in Seattle with stops in Athens and Taipei. The record stood for a month until a Gulfstream IV jet cut the time even further.

### VIP Machines and Conversions

The 747SP has been associated with VIP transport more than any other widebody, although it's since been usurped by the 747-400 and 747-8BBJ. The Saudi Arabian royal family are long-term users, as have been the Sultans of Brunei and Oman. Other examples have flown with the Qatar and the Bahrain amiri flights, and the Dubai Air Wing in the United Arab Emirates.

**BELOW • Boeing 747SP-27 A40-S0 is the personal transport of Sultan Qaboos bin Said al Said, and had a satellite communications antenna installed under a large radome on the fuselage.**  
AIRTEAMIMAGES.COM/HAMFIVE

**BOTTOM • Pratt & Whitney Canada uses two SPs for certification testing. An alternative powerplant can be installed in the number two position, or an additional engine mounted on a pylon on the right side of the upper deck.**  
PRATT & WHITNEY



## SOFIA

The most extensive modifications made to any 747SP were applied to a former United Airlines airframe, N145UA, taken on by NASA and flown to Waco, Texas, in 1999. But eight years passed before it flew again. Because the 747 had been developed before the use of computer-aided design, a model incorporating more than 150,000 airframe components had to be produced to ascertain the structural ramifications of the changes.

SOFIA's rear fuselage accommodates a 17-ton (15,420kg) infrared reflecting telescope, with primary and secondary mirrors measuring 8.2ft (2.5m) and 15in (35cm). The optical equipment is exposed to the atmosphere through a 170in x 220in (430cm x 550cm) aperture – almost a

quarter of the circumference of the airframe – cut into the rear fuselage.

The jet emerged from its \$1.1bn modification programme as N747NA in 2007, and has since been based at Palmdale in California. Flying mainly at night it gives scientists opportunities to learn more about planetary systems, the formation of stars, the development of galaxies and the evolution of the materials needed to support life. Ground-based telescopes are not effective in the infrared spectrum so, as long as funding continues, at least one SP is expected to continue flying for almost 20 more years.

**NASA's Stratospheric Observatory For Infrared Astronomy is expected to continue flying research missions until around 2035 (NASA).**



Government use of SPs also extended to countries as diverse as Iraq, Saudi Arabia and Yemen. Air Malawi even leased and repainted a South African SP for a month-long presidential visit to London in 1985.

Pratt & Whitney Canada acquired two former airline SPs, one having previously flown with Air China

and the other with Korean Air. Both became test aircraft, capable of carrying new powerplants either on the number 2 pylon or on a mount on the right side of the exterior of the upper deck. However, the most radical conversion of a 747SP was for NASA; it is known as SOFIA - the Stratospheric Observatory for Infrared Astronomy (see panel).







### Last of the Classics

Boeing sold fewer SPs than any other major variant of the Jumbo and in early 2017 only nine were still flying - none were in scheduled service. Iran Air was the last airline to fly the variant commercially, but its last example was retired in late 2016. Saudi Arabian Airlines still uses two RR-powered airframes, albeit on royal flight duties.

Pratt & Whitney Canada still operates its engine test-beds while casino and resorts operator Las Vegas Sands also flies two, one carrying 'high-roll-

ers' to gaming tables across the globe and the other acting as Chairman and CEO Sheldon Adelson's personal transport. Single SPs also remain active with NASA, the Government of Oman and Ernest Anglely Ministries while another, until recently flown by retailer Fry's Electronics, has now retired and is expected to be used for spares by NASA. The SP used by the Qatar Amiri Flight has also not flown for some time and has been for sale. Others examples are in store, although many have been scrapped and only one preserved - in

**Casino operator Las Vegas Sands has two 747SPs - one is used to fly 'high rollers' to its premises and another to for Chairman and CEO Sheldon Adelson.**

AVIATION IMAGE NETWORK/  
BRAVONOVEMBER

**Two of a kind: NASA and P&WC met for a 747SP owners' conference at Palmdale, California in 2016.**

NASA/KEN ULBRICH

the South African Airways Museum at Rand Airport near Johannesburg.

Boeing produced 722 classic 747s - including 45 SPs, only 6% of the total - but a SP could become the last of the breed to take to the air as the specialist nature of the converted airframes and the low utilisation of the VIP jets will see a few of them outlive the rest of the Classics. Meanwhile SOFIA is likely to continue its work until 2035 when it will be almost 60 years old. By then, seeing N747NA take to the air will be a Special Performance to behold. 🛫🛬





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# JUMBO-SIZE STANDARDS

OPPOSITE • Checks are carried out on an engine of a Boeing 747-200. AIRTEAMIMAGES.COM/TIM DE GROOT

Access and weight are just two of the challenges facing engineers working on the 747. The windscreen is 25ft above ground level, while the stabiliser-trim actuator weighs 565lb. AIRTEAMIMAGES.COM/EDWIN CHAI

The Pratt & Whitney (P&W) JT9D high-bypass engines used to power the Boeing 747 for its first UK demonstration flight in January 1970 were started in sequence: “three, four, two, and...” Alas, number one declined to ignite owing to a lack of fuel pressure at light-up rotation speed; several further attempts produced “only a hot starter motor” according to one person on board that day.

The problem was eventually sorted, and the Pan American World Airways (Pan Am) aircraft – *Clipper Constitution* – took off almost two hours late. Having arrived in London from New York on its proving flight earlier that day, planned visits to five other European airports had to be cancelled. The next day, 747-121,

N735PA (c/n 19642) headed back across the Atlantic.

Unfortunately, it was not the carrier’s first experience of this problem. An engine change

had delayed the 747’s departure to London and its JT9Ds did not yet include modifications already being introduced on the new engine’s pylon mounting. Like many launch customers, especially those taking aircraft with novel airframe and engine designs, Pan Am found itself “faced with more 747 maintenance problems sooner, and to a larger degree, than most other carriers”, as was described in a contemporary report.

## Developing a Plan

The advent of jetliners around 20 years earlier had seen aircraft constructors set their own maintenance programmes before an industry task force involving manufacturers, operators, suppliers, and regulators met to establish formal procedures for preventative, or “on-condition”, maintenance.

In 1968, the US Air Transport Association (ATA) maintenance steering group (MSG) published a dedicated document for the 747. According to

Boeing’s *Maintenance Evaluation and Program Development - Level 1* (dubbed MSG-1), the manufacturer used “decision logic” to develop a maintenance schedule, and it has evolved via a second 1970s’ edition into the current MSG-3.

For line- and base-maintenance engineers, the 747 posed challenges of access – windcreens were 25ft (7.62m) above ground level – and weight – the stabiliser-trim actuator weighed 565lb (255kg). Three years before its 1970 entry into service (EIS), nine teams made up from representatives from 14 airlines as well as those from Boeing and the US and British airworthiness authorities sat down to determine the 747’s many systems. This gave the industry confidence that the engineering and maintenance philosophy for the new very-large aircraft was well considered. Every month statistical information was freely exchanged among all 747 operators.

BOAC established a maintenance schedule of biennial major checks. With no more than six 747s in service, for the >>

“Alas, number one declined to ignite owing to a lack of fuel pressure at light-up rotation speed”





When the Boeing 747 was introduced into service, the aviation industry had to define new methods to maintain this giant, as **Ian Goold** discovers.







first two years maintenance was integrated with the 707 line: a huge new 747 hangar was reported to be “too valuable to be cluttered with lesser aeroplanes – space might be required at any time by a sick giant...”

Pan Am 747s logged 4,600 hours’ flying in the first two months with a 92% dispatch reliability (within 15 minutes of scheduled departure), which was regarded as good for a new aircraft. After a year’s operation, the aircraft were designated 747As having incorporated almost 200 significant engineering changes and many cabin alterations. Boeing and P&W shared most of the costs under warranty, with Pan Am covering 25%.

Early operators soon found their maintenance shops performing modifications as continued static-load testing of the wing confirmed there was sufficient strength to permit increased gross weight. For its part, Boeing soon started work on follow-on variants, the 747-200 and the stretched upper deck -300.

*Under the MSG-2 standard system, basic C-check intervals on the 747-200 are 3,600 flight hours or 15 months, whichever comes first.*

AIRTEAMIMAGES.COM/  
BRAM BOTTERMAN

*Downtime for heavy maintenance can be anywhere from 45 to 75 days.*

KEY-BARRY WOODS TURNER

## Heavy Maintenance

Taking the Series 200s and 300s as broadly representative of the work required on all 747 variants, the two models featured a typical line maintenance programme of transit, pre-flight, and daily checks with some carriers employing extended 48-hour intervals.

Most worked with the new MSG-2 standard system of C checks, with that cycle terminated by a D check at the sixth or seventh iteration.

Basic C-check intervals were 3,600 flight-hours (FH) or 15

**A huge new 747 hangar was reported to be “too valuable to be cluttered with lesser aeroplanes – space might be required at any time by a sick giant...”**



months, whichever came first. The D-check inspection period varied, starting at 25,000FH, then 22,000FH for the second interval and every 20,000FH thereafter – although airlines had some discretionary leeway.

In 2002, Boeing issued an MSG-3 programme for 747-200/-300 aircraft that extended many intervals and introduced ageing-aircraft inspections that added a corrosion protection and control programme (CPCP) and supplemental structural inspection document (SSID) tasks.

Of course, each maintenance check included the usual incorporation of engineering orders (EOs), service bulletins (SBs), and airworthiness directives (ADs). In addition, operators could also choose to include major modifica-

tions, such as additional inspections or cabin-interior work. Freighters could have cargo-handling systems checked.

Typically, such 747 work can generate around 75,000 man-hours (MH), or more if inspection reveals any ‘non-routine’ maintenance tasks necessary. Overall downtime for a heavy check can be anywhere from 45 to 75 days.

Modifications applied during 747-200/-300 maintenance to enhance airframe useful life fall into four main areas: flightdeck and avionics, engine and weight upgrades, safety, and passenger-to-freighter conversions.

Many upgrades naturally reflect technological progress. For example, before the 747-400 EIS in 1989 such engineering might have required replacement of old film-projection equipment with cabin video projectors. Then, along came traffic-alert and



collision-avoidance systems (TCAS), which led to MRO providers to market/rebrand/redefine themselves as system integration and installation services. TCAS was soon joined by other developments such as satellite-communications (satcom), reduced vertical separation minima (RVSM) requirements, and channel-spacing modifications on radio equipment.

### Modifications Required

Many different types of aircraft are lodged in the public's imagination for the wrong reasons, especially if certificates of airworthiness are temporarily withdrawn. The 747 has had its share of negative headlines, such as the Section 41 modifications. The related AD mandating the work applied to almost 700 aircraft manufactured before 1987 and required repetitive inspections of the airframe structure (such as fuselage frames, stringers and skin panels) for cracking. This damage had resulted from repeated cabin depressurisation and re-pressurisation, especially in the area where the 747's fuselage is faired into a pear-shaped cross section between the upper and lower lobes of the forward fuselage below and behind the cockpit.

Initial inspections carried out when aircraft reached 8,000 flight-cycles (FC) involved little work. Numbers of tasks increased, however, with successive events until all of Section 41 had to be checked at 19,000 FC (and thereafter at 1,500 FC or 3,000 FC intervals).

The requirement could be terminated by replacing some, or much, of the original structure and most operators took this course. Termination involved replacing most of the nose section, for which Boeing provided kits free of

*British Airways engineers work on the interior of one of the carrier's jumbos.*  
BRITISH AIRWAYS



charge. To address all nine Section 41 zones could require 30,000+MH (costing around \$2m at the time) and was usually performed during scheduled D checks.

Another high-profile modification requirement involved the introduction of new fuse pins that attach engine pylons, but are also designed to permit pylon separation to provide fuel-tank protection. Possible failure of such pins

was implicated after two engine pylons detached in flight from each of two 747 freighters in the early 1990s. This led to an upgrade, with the installation of a stronger pylon on the 747-400 which also used corrosion-resistant fuse pins. A subsequent AD required repetitive fuse-pin inspection of more than 1,000 747s, including some early Series 400s.

The CPCP currently comprises >>

*Work is undertaken on Iran Air 747-200 EP-ICD in Tehran/Mehrabad.*  
AIRTEAMIMAGES.COM/  
MEHRAD WATSON











ABOVE • **The 747-400's hangar-maintenance C-check intervals have been extended to 10,000 flight hours.**  
BRITISH AIRWAYS

FAR LEFT • **Tools of the trade: an engineer selects the spanner required for the task at hand.**  
BRITISH AIRWAYS

FAR LEFT • **A stronger engine pylon was introduced on the -400 variant.**  
BRITISH AIRWAYS

BA recently overhauled 18 747-400s, so it can continue flying them well into the next decade.  
BRITISH AIRWAYS

around 30 tasks with initial inspection thresholds of between four and 30 years, including repeat events not phased with C and D checks, while the SSID work involves structural inspections performed during C and D checks. Other elements of the ageing-aircraft programme are inspection of structural repairs 15,000FC after they have been performed and checks for widespread fatigue damage, especially where it is found in several places on one airframe, or on several machines in a fleet.

### Revising Requirements

In 1999, airline customer requests led Boeing to review maintenance programmes for out-of-production aircraft, almost ten years after the last 747-300 had been delivered. The manufacturer today states that because the 747-100/-200/-300 'Classic' variants and the later 747-400 (which was in production from 1987 to 2009) were structurally similar, the company and the wider industry decided to update the latter's maintenance procedures simultaneously.

The new requirements complied with MSG-3 standards (also used to develop scheduled maintenance requirements for the 777, 737NG and 717). Two industry steering committees (ISCs), each comprising the manufacturer, operators, and the FAA, were established to revise

the two 747 maintenance programmes.

More than half of the 747 Classic fleet and 70% of -400s were involved in the three-year effort that culminated in respective Maintenance Review Board (MRB) Reports, which Boeing said could "help operators significantly reduce maintenance costs".

Using data reported by airlines using MSG-3 programmes for contemporary McDonnell Douglas MD-80, DC-9, DC-10, and DC-8 aircraft designs, the manufacturer suggested up to 30% "annual savings for 747 operators".

Economies were expected to be achieved through increased inspection intervals between checks, elimination of redundant and inefficient tasks, efficient packaging of requirements, enhanced Classic/-400 commonality, refined 747-400 system and powerplant requirements, and alternative means of compliance with corrosion requirements.

In 2008, Boeing reported that among 747-400 operators using MSG-3 procedures, one major carrier had increased availability to the equivalent of nearly one additional aircraft annually, while another had reduced D-check downtime from 42 days to 28 days.

Boeing claims that MSG-3's task-

oriented approach analyses failure modes from a system level, or top down. Tasks are performed for economic, operational, or safety reasons, involving both preventative maintenance and failure detection. Subsequent revisions have extended the philosophy to cover all modes of failure, including corrosion prevention and control, enhanced structure zonal analysis and lightning/high-intensity radiated fields.

Like earlier variants, the 747-400 has seen hangar-maintenance C-check intervals grow steadily from 4,000FH at EIS to 5,000FH in 1994, 6,000FH after 2001, and 10,000FH from 2010.

Boeing describes the 747-400 heavy-maintenance interval as unique: "The MRB D-check requirement calls for six-year intervals [with no] flight-hour cap. This means that annual utilisation will not impact [D-check] frequency [which] will be determined by a calendar-time limit only." Some operators have escalated D-check intervals from six to eight years, again without any FH limitation.

Nearly 30 years after EIS, many airlines still operate 747-400 passenger services. For example, British Airways has the largest such fleet, with around 50 in operation, of which perhaps around a dozen are stored, and has not announced for their complete retirement. Indeed, the carrier has recently refurbished the passenger cabins on 18 examples, which suggests intent to fly the aircraft for several more years.


Having unveiled potential 747-500X, -600X, and -700X schemes at Farnborough in 1996 (only to formally shelve the first two a few months later, with no subsequent reference – ever – to the last mentioned),

Boeing spent many years and blunted myriad pencils sketching other hypothetical 747 developments, having unveiled potential 747-500X, -600X, and -700X schemes at Farnborough Airshow in 1996, only to formally shelve the first two a few months later. There was no subsequent reference – ever – to the latter.

After one aerospace analyst counted at least 23 possible/maybe/ perhaps variants, often of the 'GTXL' variety, Boeing in 2002 revealed 747 models dubbed 'XQLR'!

Alas, neither did this emerge from the hangar, although some elements graced the '747 Advanced' project that later became the 747-8, or, more properly, the 747-800, that was launched in 2005 and entered service in 2011. Accordingly, it will be later this year before a 747-8 falls due for its first systems heavy-maintenance D check.

Related inspections of the airframe structure are scheduled to follow in 2019.

Unfortunately, Pan Am, whose 64-year history story came to an undignified end in 1991, isn't in a position to put Boeing's latest type through its paces. 

Boeing describes the 747-400 heavy-maintenance interval as unique

OPPOSITE • **A wheel is replaced on a British Airways 747.**  
BRITISH AIRWAYS



# Flying Palaces

**James Ronayne** shines the spotlight on the money-go round of VIP 747s worldwide.



Is there a better indication of wealth than having your own Boeing 747? The 'Queen of the Skies' has proven very popular with extremely high net worth individuals, royalty and governments, particularly those based in the Middle East.

The manufacturer's entire in-production airliner range is available under the Boeing Business Jet (BBJ) brand. While it does offer its own cabin outfitting, the firm has provided this service for only three aircraft so far, and has yet to work on the interior of a 747. Most customers opt to use a specialist third party, such as Lufthansa Technik or Jet Aviation of Basel, Switzerland, for the work. These companies have design teams who work with their clients to customise their cabin, right down to the tiniest of details. One customer is reported to have spent \$200m on the cabin outfitting alone.

Lufthansa Technik says the type "offers extensive space for prestigious reception, living and business", adding "its dimensions enable a level of comfort that is hard to match even on the ground".

The VIP version of the 747-8 offers 4,786sq ft (444.6m<sup>2</sup>) on the main deck. By incorporating the SkyLoft area, which is located above the main cabin between the upper deck and tail, there is potential for 881 sq ft (81.8m) of additional cabin space giving owners the opportunity to create unique personal suites, private offices and

**ABOVE • Worldwide Aircraft Holding's 747SP-21 VP-BAT raises the gear on departure from Paris/Le Bourget.**  
AIRTEAMIMAGES.COM/  
MATTHIEU DOUHAIRE

**Palace in the Sky:** specialist third parties – such as Lufthansa Technik – work with owners to customise the cabin.  
LUFTHANSA TECHNIK



recreational spaces.

Boeing says that the BBJ 747-8 can carry 100 passengers up to 9,260nm (17,150km). It also claims the aircraft is the fastest large-cabin business jet, capable of cruising at Mach 0.86. It has so far sold and delivered three BBJ 747-400s and eight BBJ 747-8s.

## Royal Rumble

One of the largest fleets of VIP-configured 747s is in Saudi Arabia, namely a pair of 747SP-68s and a single -300 and -400 variant. The two SPs, HZ-HM1B (c/n 21652) and HZ-HM1C (c/n 22750), were both delivered new to Saudi Arabia in July 1979 and May 1982

**Japan's Air Self-Defense Force uses two 747-400s for government duties. The type is due to be replaced by the 777-300ER.**  
AVIATION IMAGE NETWORK/  
SIMON GREGORY







2004 as P4-FSH and is still active for the Christian evangelist group.

The Abu Dhabi Amiri Flight, responsible for government air transport, flew 747-48E(M) A6-UAE (c/n 28551) from 2004 until December 2015. The former Asiana Airlines and Air Namibia example is now with the Moroccan

“its dimensions enable a level of comfort that is hard to match even on the ground”.

Lufthansa Technik

respectively, with the former operating commercial passenger services with Saudi Arabian Airlines (SVA) as HZ-AIJ until November 1982.

Boeing 747-3G1 HZ-HM1A (c/n 23070) was delivered new to the Saudi Government in 1983 while -468 HZ-HM1 (c/n 28343) was handed over to SVA in March 2001. It served with the carrier until October 2007 when it was transferred to government operations, eventually entering service as a VIP-configured jet in June 2011. They all fly in the colours of SVA and are operated by the carrier's Saudi Special Flight Services.

The Dubai Air Wing, the paramilitary airline of the Dubai Government, currently operates two 747-400s, A6-MMM (c/n 26906) and A6-HRM (c/n 26903), both of which were previously with United Airlines and delivered to the UAE in May and September 2003 respectively.

They replaced a pair of former Trans World Airlines (TWA) 747SP-31s, A6-SMR (c/n 21961) and A6-SMM (c/n 21963), that had joined the Air Wing in February 1985 and December 1994 respectively. 'Mike Romeo' was sold to leasing company Interface Operations in June 2007 and is now flying VIPs around for the Nevada-based Las Vegas Sands Corporation as VP-BLK. Its former sistership, 'Mike Sierra' joined the Ernest Angley Ministries in November

**BELOW • Oman has been a loyal Boeing 747 operator. As well as SP-27 A4O-SO it also has a -400, A4O-OMN, and is in the process of adding an -8, A4O-HMS.**

AIRTEAMIMAGES.COM/  
DIRK GROTHE

**BOTTOM • Lufthansa Technik has produced this bedroom concept for potential 747-8 customers.**

LUFTHANSA TECHNIK

Government as CN-MBH. It has been replaced by 747-8Z5 A6-PFA (c/n 37500).

The Royal Flight of Oman is another loyal VIP 747 operator. It has operated former Braniff International Airways 747-SP-27 A4O-SO (c/n 21785) since July 1984 and took on 747-430 A4O-OMN (c/n 32445) in 2004. Its next addition, 747-8 A4O-HMS (c/n 30749), first flew in November 2012.

Another Gulf state using the 747-8 is Qatar, which has two operated by its Amiri Flight on government and royal duties. The first jet, which was originally registered A7-HJA (c/n 37075), was ferried from Wichita, Kansas, to Basle in Switzerland in April 2012 for cabin outfitting by Jet Aviation. Having been reregistered A7-HBJ, it was delivered to Doha in July 2015. The second airframe, A7-HHE (c/n 37544) flies in full Qatar Airways livery and was handed over in February 2012.

Bahrain currently has 747-4P8, A9C-HMK (c/n 33684) and 747SP-Z5 A9C-HAK (c/n 23610) which are used for royal and government duties.

Former Boeing 747-8I demonstrator N6067E (c/n 8636), was flown to Kansas City in November 2012 where it was fitted out for the Kuwaiti Government. In February 2016 it was delivered from >>





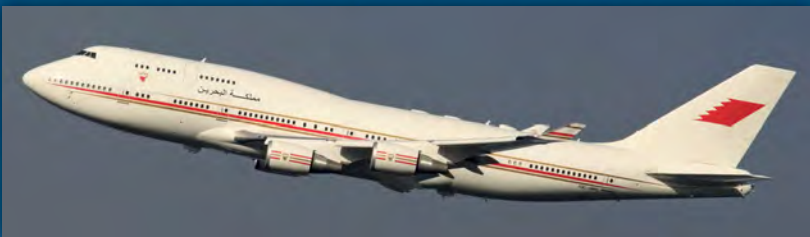
Passengers on board Las Vegas Sands' 747SP can enjoy leather couches and plenty of leg room.

AIRTEAMIMAGES.COM/ YOCHAI



Bahrain's 747-4P8 A9C-HMK climbs away from London/Heathrow against a moody sky.

AVIATION IMAGE NETWORK/ SIMON GREGORY



Morocco's 747-48E, CN-MBH, has a history of undertaking VIP work having been acquired from the Abu Dhabi Amiri Flight.

AIRTEAMIMAGES.COM/ MATTHIEU DOUHAIRE

Dallas/Love Field to Kuwait as 9K-GAA. Japan's Air Self-Defense Force operates two aircraft on government duties.

The two 747-47Cs were first delivered to the Japanese Government in September 1991, transferring to the military in April 1992.

The purpose-built jets are due to be replaced shortly by a pair of Boeing 777-300ERs. Japan's neighbour South Korea has recently taken on a Korean Air 747-4B5,

10001 (c/n 26412), for official duties while the Sultan of Brunei has been using V8-ALI (c/n 26426), a 747-430, since April 1992.

### VC-25

The most iconic 747s in service today are the United States Air Force's (USAF's) VC-25s, which are used as the presidential transport. Although commonly referred to as Air Force One, this is actually the callsign that applies to any aircraft carrying the President.

Two VC-25s were acquired by the USAF in 1990. The jets are heavily modified 747-200Bs providing 4,000sq ft (371m<sup>2</sup>) of interior floor space and capable of carrying 102 people. Included on board are a conference/ dining area, quarters for the President and First Lady, offices for senior staff, a medical facility and work and rest areas for the crew, staff and press corps.

The VC-25 is air-to-air refuelling capable and is completely self-sufficient when on the ground; it even features a self-contained baggage loader.

Boeing successfully bid to replace the VC-25 with a new design based on the 747-8I. However, President Donald Trump has called the purchase into question due to programme costs.

### High Net Worth Individuals

Bournemouth Airport in Dorset is home to two private 747s – VP-BAT (c/n 21648) an SP-21, and BBJ 747-8 VQ-BSK (c/n 42096) – both registered to Worldwide Aircraft Holding.

Kingdom Aircraft's 747-4J6, HZ-WBT7 (c/n 25880), has been operating for the Saudi registered firm since July 2005 and is the personal transport of Prince Al-Waleed Bin Talal, a Saudi businessman and member of the royal family.

As well as the previously mentioned VP-BLK, the Las Vegas Sands Corporation also operates 747SP-21 VQ-BMS (c/n 21649) to fly clients between its casinos in the US and Asia.

While commercial airlines continue to shed their 747s in favour of more efficient new-generation airliners, the jumbo looks set to continue in the private and government market, as the ultimate jet of choice for VIPs and royalty worldwide. *✈️*





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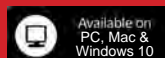
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# The 21st Century Cabin



*Airliner World's* **Barry Woods-Turner** visited British Airways at Heathrow to discover how the airline has refreshed 18 of its Boeing 747-400s to help keep the type in service well into the next decade.

*BA has refurbished  
18 of its Boeing  
747-400s, enabling  
the jets to continue  
flying well into the  
next decade.*  
AIRTEAMIMAGES.COM/  
ISMAEL JORDA





**ABOVE LEFT • Club Class has been increased in size by 16 seats.**

ALL PHOTOS BRITISH AIRWAYS UNLESS STATED

**ABOVE • A new IFE system has been installed across all cabins.**

**Fabric was replaced on 4,950 seats during refurbishment of the 18 jumbos.**

**Three hundred captains and 400 first officers are employed by the airline on the 747 fleet.**

they are all the same. This gives our passengers a more consistent experience."

She explained the airline took the 'blueprint' used for the A380/787 and laid it over the 18 747s, investing in the necessary changes where they would matter most. The First Class cabin had been refurbished only a few years before, so aside from replacing seat foams and fabrics to improve the aesthetics, along with a general tidy up, the front portion of the aeroplane was largely untouched.

Major work centred on Club Class. Doyle said: "Again we had a change of foams and fabrics, but the biggest job was the reconfiguration of the cabin which we increased in size with an additional 16 seats. With such a major programme of work being undertaken, it was agreed that a new in-flight entertainment system (IFE) would be installed across all cabins. We naturally looked at what cabin

»

Major airlines around the world continue to retire four-engined jet airliners and replace them with the latest generation of economic twins. One carrier has decided to buck this trend and breathe new life into its Boeing 747 fleet. Between August 2015 and 2016, British Airways (BA) carried out an ambitious project to refurbish 18 of its 38-strong 747 fleet, enabling the aircraft to fly on well into the next decade. The work was carried out by the airline's engineers at its Cardiff base and involved a cabin interior refresh, bringing it in line with its newest types, the Airbus A380 and 787 Dreamliner.

### Cabin Refurbishment

Airline World spoke to Kathryn Doyle, BA's Product Development Cabin Interiors Manager, who with her team of five were responsible for delivering the upgrades. It is this team which looks after the entire product life cycles for the whole of the BA fleet.

Around two years before the first refurbished 747 was returned to service, the airline was looking at what it was going to do with its remaining jumbo jets. It had identified that with cheaper fuel prices these aircraft were good

assets and still had plenty of flying life left. They were economically viable and offered the right range and flexibility the carrier needed. Doyle said: "We selected the 18 youngest aircraft in the fleet. Against a background of types being retired, these jets have the greater flying time remaining. So again, the airline was investing in aircraft that it believed we would get the biggest return. The 747s have a real purpose in the BA fleet."

So, the question was, how does the airline keep them competitive?

Doyle explained: "We undertook a nose to tail review of the cabins, and found that all differed in one way or another, each have been updated at different times. So immediately there was an opportunity to standardise the cabins of at least some of the fleet. When we brought the A380 and 787 Dreamliner into service in 2013 we tried to apply what we call our 'design blueprint'. This delivers a more homogenous BA experience for passengers. So, it doesn't matter what aircraft you are flying in, this constant design philosophy across the airline means you will recognise that you are flying with BA. Small touches like carpets and curtains used to be different colours in each cabin, now







upgrades other airlines were doing and had been able to get some valuable hints and tips that we were able to encompass in what we were planning.”

The installation of new LED lighting has also improved the cabin enormously. Doyle said the main driver behind the cabin upgrade was keeping the carrier’s 747s competitive and an attractive proposition for customers to want to continue flying on them. “We all have an emotional attachment to the 747, and that is something that the cockpit and cabin crews have commented on - the fact that BA is investing in the aircraft has

made them feel even prouder and this has been reflected in an improvement of the service we give our passengers. We have also seen this reflected in our customer voice surveys, while we didn’t change the food and drink menus or the crews, we have seen the scores go through the roof compared to the rest of the fleet that we haven’t refurbished.”

The first 747 went into the modification programme in August 2015 and the last one left 12 months later. It took around 18 months to work up the programme and get the necessary management approvals as

*BA has been a loyal 747 operator, flying the -100, -200 and -400 variants.*

well as lining up the supplier chain. Doyle said: “An aircraft programme such as this has a standard flow, you have meetings at set intervals and that is your ‘ticking clock’. It will be around another year from the initial meeting to the on-dock date, when a seat for instance, must be delivered ready for installation. So, it was probably nearly two years before that we started the process of looking at the 747 upgrade.”

Most of the cabin modernisation was carried out by British Airways Engineering at Cardiff in South Wales. British Airways Interiors Engineering at nearby Blackwood did most of the seating overhaul by stripping and deep cleaning them, putting in a new foam and in-flight entertainment (IFE) system, before being returned ready for installation.

Doyle concluded: “Within the constraints of the older airframe, we have done our best to replicate the cabins of the newer aircraft now entering the BA fleet. The 747s have the same soft furnishing, coverings, although the retrofitted LED lighting isn’t so sophisticated. But the IFE is a more up-to-date system than on its newer stablemates. We cannot get away from the age of the airframe, the jumbo is what it is. The 747 refresh was the biggest retrofit programme ever undertaken by BA and will only be surpassed by work it is planning to carry out on its 777 fleet next year.”

*The airline is now rolling out an on board Wi-Fi system across both its long- and short-haul fleets. Boeing 747-436 G-CIVV has already had the equipment installed.*



## 747 Refurbishment Key Facts

- 61 miles of wiring for the new Panasonic eX3 IFE system
- Enough new carpets to cover 34 tennis courts
- Nearly six miles of new LED lights
- 4,500 light fittings
- Fabric changes to 4,950 seats





*New recruits to the 747 go through two weeks of ground school and 11 training sessions culminating in a Licence Skill Tests, before embarking on line flying with an experienced training captain.*

*ABOVE RIGHT • The carrier has four 747-400 simulators at its Learning Academy at Heathrow.*

## A Connected Aircraft

Richard D'Cruze, BA's Head of In-Flight Entertainment, said IFE on the long-haul fleet was a key factor when talking about passenger satisfaction. He is responsible for the airline's strategy regarding in-flight entertainment systems, from the hardware fitted to the carrier's aircraft through to the content management of what passengers view.

D'Cruze explained: "We place a huge importance on IFE, that is why we invest so much time and money in providing an excellent product for our customers. Our main strategy is to try and reflect major entertainment trends that are available on the ground,

and put them in the sky. IFE is very much about providing enough content and choice for the passenger; our customers expect and we aim to provide them with as much as possible. As an airline, we can generally show films on board three months after they are released in the cinema and three months before they are released on DVD or Blu-ray. Providing the latest releases is one of our priorities as we know these are the most popular with our customers."

British Airways will shortly roll out the next stage of its connectivity strategy with the addition of on board Wi-Fi, this D'Cruze said, would open endless possibilities including live-streaming of television programmes

such as news and sporting events. "We are currently trialling a system that we will fit to both our short and long-haul fleets, including the 18 refurbished 747s. We are seeking to connect 90% of our fleet by 2019. So right now, the programme is right at the beginning, we have just completed our first install and it just happens to be on a 747 (G-CIVV) and we are just undertaking testing right now. The aircraft is easily recognisable as it has a visible hump on top of its fuselage which contains the Wi-Fi satellite antennas."

D'Cruze couldn't confirm how long these tests would take, but hoped to make a further announcement soon. He added: "We need to have staff on board to run the trials, so even if the >>

**"The 747 refresh was the biggest retrofit programme ever undertaken by BA and will only be surpassed by work it is planning to carry out on its 777 fleet later this year."**

BA Product Development Cabin Interiors Manager  
**Kathryn Doyle**

*The 747 continues to attract pilots despite the advent of newer technology, such as the Airbus A380 and Boeing 787.*

AIRTEAMIMAGES.COM/LEXY





aircraft is flying a lot, it isn't always possible to have our testers on board. I think it is great that we have chosen to install the system on a 747, as it shows we are still investing in the jet.

"During the reconfiguration of the 18 747s we have taken the opportunity to do a product refresh that will help sustain the fleet for longer. One of the biggest pieces of work has been the installation of a new IFE system. The aircraft was previously fitted with a Rockwell Collins product which had been around since the 1990s. We have now fitted the Panasonic eX3 – one of the latest systems currently flying. What this gives our customers is four times the content storage (over 1,300 hours of entertainment including more than 130 movies and 400 TV programmes), a much bigger screen to watch it on and overall an improved viewing experience. The touchscreens are a higher resolution and are very much like iPads in terms of response, giving a very modern feel to the system. Each seat back system has pre-loaded content so should there be any issues with the servers at the front of the aeroplane, a customer's entertainment will not be interrupted."

The new IFE has scored very well on customer surveys, with an impressive 40% increase in satisfaction, a result D'Cruze said was "very satisfying". He added: "We have to be pleased with this feedback". In terms of content, passengers on the 747s get the same as those flying on the A380/787, they also get the large touchscreens and noise cancelling headphones. However, the technology is slightly different. Specifications for the A380/787s were finalised in 2008/09, but in the intervening years technology has moved on, so the system fitted on the 747s has slightly higher resolution monitors, brighter image quality and a more responsive touchscreen.



*Boeing 747-436 G-CIVX is one of the 18 aircraft refurbished with the new cabin product.*  
KEY-BARRY WOODS-TURNER



**Keeping the 747s Flying**

Airliner World also spoke to Captain Ian Pringle, Flight Training Manager for the 747-400. BA currently has more than 4,000 pilots, of which 300 captains and 400 first officers are employed on the jumbo jet fleet. There are more first officers because long-range sectors require an augmented crew, typically consisting of one

*Installation of the Panasonic eX3 IFE system required 61 miles of new wiring to be fitted inside the aircraft.*  
KEY-BARRY WOODS-TURNER



captain and two first officers, to enable extended crew duty periods.

Notably, the carrier continues to add new cockpit crews to its 747 roster. Capt Pringle explained: "The previous two years have been exceptionally busy from a pilot training perspective as we have recruited nearly 800 new pilots across the airline. This number alone is equivalent to the size of a large UK airline. As part of this, we have conducted around 270 conversion courses onto the 747, representing a mix of internal moves and direct entry pilots (experienced pilots from other airlines)."

He explained a typical conversion course for a new pilot to the 747 encompassed three stages. The first entails around two weeks of ground school, which includes computer-based and fixed-based simulator training. This leads on to 11 training sessions in a full-flight simulator, culminating in the Licence Skill Test (LST) and a zero-flight time detail – where the simulator is used in place of a non-revenue aircraft exercise. The final stage is the line flying element where a newly qualified pilot operates revenue flights under the supervision of an experienced training captain.

Asked about the challenges of flying the 747, Capt Pringle responded: "From a pilot's perspective, the eye height – around 13ft (1.5m) higher than that of the A380 – this takes a little time to get used to. Also, there is a lower sensation of speed during taxi, and, of course, when it comes to landing, the flare height appears higher." All of these were areas the author struggled with during an exciting (and at times stressful) 40-minute simulator ride sitting next to Capt Pringle on one of the four 747-400 full-flight simulators the airline operates at its new Learning Academy at Heathrow.

Asked whether pilots still wanted to fly the 747 or was the allure of the new technology jets such as the A380 and 787 a bigger motivator, Capt Pringle reflected: "During their career at BA, pilots are able to transfer from one type to another at various points and the 747 fleet continues to be a very popular choice. The jet is very much a pilot's aircraft – you 'feel' in tune with the machine and it has great handling characteristics. It is held in great affection by those who fly it." ✈️

The author would like to thank Kathryn Doyle, Richard D'Cruze, Captain Ian Pringle and Michael Johnson for their help in preparing this article.

*Captain Ian Pringle says the 747 is held in great affection by those who fly it.*



BA has more than 4,000 pilots, of which 300 captains and 400 first officers are employed on the jumbo jet fleet.



*Kathryn Doyle says the 747s continue to have a "real purpose in the BA fleet".*



# In Numbers

Specifications						
Variant	747SP	747-100	747-200B	747-300	747-400	747-8
Cockpit Crew	Three	Three	Three	Three	Two	Two
Seating (typical)	276	366	366	400	416	467
Length	184ft 9in (56.3m)	231ft 10in (70.66m)	231ft 10in (70.66m)	231ft 10in (70.66m)	231ft 10in (70.66m)	250ft 2in (76.25m)
Wingspan	195ft 8in (59.6m)	195ft 8in (59.6m)	195ft 8in (59.6m)	195ft 8in (59.6m)	211ft 5in (64.4m)	224ft 7in (68.4m)
Wing area	5,500sq ft (511m²)	5,500sq ft (511m²)	5,500sq ft (511m²)	5,500sq ft (511m²)	5,650sq ft (525m²)	5,960sq ft (554m²)
Tail height	65ft 5in (19.9m)	63ft 5in (19.3m)	63ft 5in (19.3m)	63ft 5in (19.3m)	63ft 8in (19.4m)	63ft 6in (19.4m)
Empty weight	337,100lb (152,900kg)	379,500lb (172,100kg)	375,100lb (170,100kg)	384,000lb (174,000kg)	412,300lb (187,010kg)	485,300lb (220,128kg)
MTOW	700,000lb (320,000kg)	735,000lb (333,000kg)	833,000lb (378,000kg)	833,000lb (378,000kg)	910,000lb (412,760kg)	987,000lb (447,696kg)
Cruise speed	505kts (935km/h)	490kts (907km/h)	490kts (907km/h)	523kts (969km/h)	504kts (933km/h)	504kts (933km/h)
Takeoff	9,250ft (2,820m)	10,650ft (3,250m)	10,900ft (3,300m)	10,900ft (3,300m)	10,700ft (3,260m)	10,200ft (3,100m)
Range	5,830nm (10,800 km)	4,620nm (8,560 km)	6,560nm (12,150 km)	6,330nm (11,720 km)	7,670nm (14,200km)	7,730nm (14,320km)
Turbofan engines (×4)	JT9D, RB211	JT9D	JT9D, CF6, RB211	JT9D, CF6, RB211	PW4000, CF6, RB211	GEnx-2B67
Thrust (per engine)	46,300–56,900lb	43,500–51,600lb	46,300–54,750lb	46,300–56,900lb	62,100–63,300lb	66,500lb

Production											
Model	Orders	Deliveries	Outstanding	Model	Orders	Deliveries	Outstanding	Model	Orders	Deliveries	Outstanding
747-100	167	167		747-300	56	56		747-400F	126	126	
747-100B	9	9		747-300M	21	21		747-400M	61	61	
747-100SR	29	29		747-300SR	4	4		747-8	48	41	7
747-200B	225	225		747-400	442	442		747-8F	88	69	19
747-200C	13	13		747-400D	19	19		747SP	45	45	
747-200F	73	73		747-400ER	6	6		E-4A/B	4	4	
747-200M	78	78		747-400ERF	40	40		747 Total	1,554	1,528	26





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